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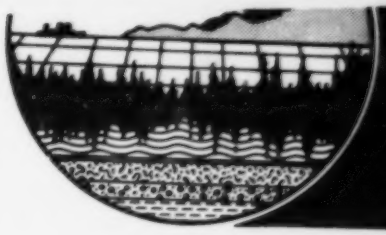

LANDS DIRECTORATE

DIRECTION GENERALE DES TERRES

LAND USE CHANGE ON WETLANDS IN SOUTHERN CANADA: REVIEW AND BIBLIOGRAPHY

WORKING PAPER No. 26

Environment Canada Environnement Canada

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LAND USE CHANGE ON WETLANDS IN SOUTHERN CANADA: REVIEW AND BIBLIOGRAPHY

Pauline Lynch-Stewart

April 1983

CANADA LAND USE MONITORING PROGRAM

Lands Directorate
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Changement d'utilisation des terres
terres dans les milieux humides du Canada:

ABSTRACT

The study of wetlands from a land use change perspective has been selected as the second component of the Prime Resource Lands Project, Canada Land Use Monitoring Program. This report examines the existing information on wetland conversion, to serve as a basis for the design and focus of a national land use monitoring project.

The report consists of four major sections. A literature review summarizes the nature and scope of existing information sources and identifies major data gaps. A national overview examines the conversion of wetlands to agricultural use, urban and industrial development, energy-related development and recreational use. A geographical breakdown of nationally and regionally-significant issues is provided for each land use type. The final sections present a summary and conclusions related to wetlands conversion across southern Canada with general recommendations. Detailed descriptions of the quantitative data bases identified, and brief annotations of the qualitative sources, are appended to the report.

RÉSUMÉ

Dans le cadre du Programme de surveillance de l'utilisation des terres au Canada, on a choisi, comme deuxième élément du projet "Terres de choix", l'étude des terres humides du point de vue du changement dans l'utilisation des terres. On examine dans le présent rapport les renseignements existants sur la conversion des terres humides; cette étude servira de point de départ pour établir le plan et la portée d'un projet national de surveillance de l'utilisation des terres.

Le rapport comprend quatre sections principales. D'abord, on fait une étude bibliographique pour résumer la nature et la portée des renseignements existants, en préciser les sources et en relever les principales lacunes. Ensuite, on donne un aperçu natinal de la conversion des terres humides pour l'agriculture, l'expansion urbaine et industrielle, la production d'énergie et des loisirs. Puis, pour chaque mode d'utilisation, on fait une étude géographique détaillée des questions qui sont importantes à l'échelle natinale et au plan régional. Enfin, on présente dans la section finale un résumé et des conclusions relativement à la conversion des terres humides dans le sud du pays ainsi que des recommandations générales. Le rapport contient en annexe une description détaillée des bases de données qui ont été mentionnées ainsi que de brèves notes explicatives sur les sources qualitatives.

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PHOTO CREDITS

Plate 1: Location - Cap Tourmente, Southern Quebec. Canadian Wildlife Service Interpretation Slide Collection, Ottawa, Ontario.

Plate 2: Location - Minnedosa Pothole Region, Southwestern Manitoba. Dr. Adams, Canadian Wildlife Service, Saskatoon, Saskatchewan.

Plate 3: Location - Lake St. Clair, Southern Ontario. G. McCullough, Canadian Wildlife Service, London, Ontario.

Plate 4: Location - Second Marsh, Oshawa, Ontario. J. Carroll for Environment Canada, Burlington, Ontario.

Plate 5: Location - Lake St. Clair, Southern Ontario. G. McCullough, Canadian Wildlife Serivce, London, Ontario.

PREFACE

This working paper is the result of a contract by the Lands Directorate to investigate and report on the current status of knowledge concerning the effects of land use change on wetlands across Canada. It is a preliminary step in developing an overall approach, not only by the Lands Directorate but also by the Environmental Conservation Service of Environment Canada, towards a coordinated, effective strategy for wetland conservation and management in Canada. The contents of this report are the result of diligence and persistence in acquiring widely scattered data, suggestions, and opinions by the contractor, Pauline Lynch-Stewart. The contents of this report have been carefully edited; however should errors or omissions exist and be brought to our attention, we would be most grateful.

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1.0 INTRODUCTION

In their natural state, wetlands provide hydrological, ecological, recreational and other functions vital to the well-being of Canadians. However, wetlands are increasingly being converted from their natural state to support alternative land uses such as agriculture, urbanization, industrial development, and recreation. The diversity of competing uses and resource values associated with wetlands (including the environmental implications of disrupting wetland functions) has resulted in a resource-use conflict of national scale and concern.

Wetlands have traditionally been regarded as unexploited wastelands and obstacles to development and production. Their perceived value has depended primarily on their potential for conversion to more "productive" uses. Although the value of their natural functions has been more widely recognized over the past decade, there remains a major hindrance to preserving wetlands: the inability to express this value in meaningful terms within the present systems of resource allocation.

The nation's wetland resource has also been plagued by a number of other constraints which are typical of major issues regarding land use and land use change. Fragmented jurisdiction, spreading responsibility for wetlands among many federal, provincial, and municipal agencies, has weakened the possibility of wise management. Protective measures have been largely reactive in nature, providing only ad hoc responses to development threats. The very nature of land use change on wetlands across the country, with significant amounts of conversion occurring incrementally, makes sound management of the wetlands resource even more difficult.

Evidence of a decline of the wetlands base and implications of that decline, as well as the growing number and intensity of land use conflicts, clearly indicate that a change in the approach to wetlands management in Canada is essential. Such natural resource planning is dependent on an accurate appraisal of the situation; there is, however, a dearth of information regarding the nature, extent, and timing of land use change on wetlands.

The objective of the Canada Land Use Monitoring Program (CLUMP) is to monitor the amount, location and type of land use in Canada on national and regional scales in order to produce statistics on land use trends, and national and regional data sets and reports on land use change. The CLUMP program has the potential for valuable contribution to the information requirements of wetlands management across Canada.

The Prime Resource Lands (PRL) program is one component of CLUMP. The study of wetlands from the perspective of land use change has been selected as the second project of the PRL program. "Prime Resource Lands" are those lands which are considered "special", "unique" or "critical", and are usually defined according to the inherent physical and environmental qualities and socio-economic factors which interact to produce goods and services. The latter are essential to the economic, environmental, and social well-being of Canada. Wetlands fulfill these criteria through various functions: water absorption and storage,

which reduce the potential for flooding especially in urban areas, and regenerate groundwater supply; the improvement of water quality by reducing nutrient load, trapping sediment and pollutants, and increasing oxygen content; the protection of shorelines by providing a physical buffer to wave-energy impact; the provision of breeding, nesting and feeding grounds and predator-escape cover for many species of mammals and birds, particularly along major flyways as production and staging areas for migratory birds; the provision of spawning and nursery grounds for freshwater fish, saltwater shellfish, and finfish, serving as outdoor educational exhibits and scientific laboratories; and providing recreation and an aesthetic break from the urban environment.

In essence, "Prime Wetlands" include those wetland environments in Canada which exemplify nationally important values and which are or will be under pressure for conversion to other uses. All types of wetlands, including coastal and shore marshes, inland bogs, swamps, fens and shallow-water areas, particularly in southern Canada, are considered to be "prime", especially those which are representative of the wetland regions of the nation. Also of importance are the external agents causing wetland conversions, such as agriculture and urban expansion, industrial infilling, pipeline or reservoir construction, and harbour and marina development. In many cases, these agents are directly or indirectly tied to federal programs and policies (Lands Directorate, 1982).

The basic definition of "wetland" adopted for this PRL study is that of Tarnocai (1979): "land having the water table at, near, or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophylic vegetation and various kinds of biological activity which are adapted to the wet environment". However, it was necessary to accept other definitions in the literature due to the absence of a standard wetland definition used in research across the country.

This document reports on the initial phase of the CLUMP Prime Wetlands study. It is the result of a four-month investigation into existing sources of information related to land use change on and adjacent to wetlands. The investigation included a survey of individuals involved in wetland-related research and management (Appendix 3), and sought nation-wide participation of government agencies, private firms, educational institutions, and interest groups (Appendix 2). The report was compiled primarily from information received or referenced in response to the survey, and from interviews with key research personnel across Canada.

The report consists of five major components:

(1) A literature review, which identifies the nature and scope of the existing information sources and major gaps in that information.

(2) A national overview of land use on and adjacent to wetlands which have been, are or may be under pressure for conversion to other uses. This overview

addresses such issues as the conversion of wetlands to agricultural use, urban and industrial development, energy-related development, and recreational use. A geographical breakdown of nationally and regionally significant issues is provided for each land use conversion.

(3) A summary and conclusions related to wetland conversion across southern Canada are presented.

(4) Specific recommendations regarding the design and focus of future research on wetland land use conversion are also presented.

(5) Descriptions of the quantitative data bases used in the overview and brief annotations of the qualitative sources cited are included in Appendices 1 and 4.

This paper focuses on wetland conversion to other uses, and does not deal with the issue of indirect impact of land use activities on wetland ecology. The latter is recognized as a significant factor in wetland degradation, but is beyond the scope of this paper.

Plate 1: In their natural state, wetlands provide hydrological, ecological, recreational and other functions vital to the well-being of Canadians.

2.0 THE ISSUES OF LAND USE CHANGE ON WETLANDS

Sources describing the biophysical aspects of wetlands abound, as do those which address their social value or ecological role. There also exists a growing body of literature which discusses the implications of the loss of wetlands. However, there is a paucity of documentation defining the nature and extent of land use change on wetlands in Canada. Of the pertinent information available, most is either extremely general or locally focussed, making a national overview of wetland conversion difficult to achieve. This information is summarized in Table 1.

Less than 5% of southern Canada has been studied from the perspective of land use change, which is minimal considering that 18% of Canada's land surface is comprised of wetlands. Although not all of these wetlands are under pressure for conversion, there are many significant wetland areas which are in need of study.

The nation-wide concern for land use change on wetlands is unmistakable. Many of the individuals contacted during this investigation noted the dearth of existing data sources, and stressed the need for research into issues regarding wetland conversion. As an initial step in the development of management strategies, much research across the country is currently directed at the inventory, evaluation and priority assessment of wetlands which recognizes the need for a balance between preservation and development in order to ease conflict over the wetland resource. The inventories are viewed by many resource managers as the basis for an ongoing program of monitoring wetlands. The inventories, evaluations, and priority studies identified during the course of this research are listed in Table 2. References to them are provided in the Bibliography and in Appendix 4.

In addition to general wetland inventories and assessments which are based on concern for conservation, specific peatland inventories are being conducted for resource development. Several provinces are determining the extent, location, depth and quality of peat resources which have the potential for development as an alternative energy source.

In general, the diversity of agencies responsible for or interested in wetlands contributes to a wide-ranging set of information sources (Appendix 2). Departments of agriculture, natural resources, and environment at both the federal and provincial levels are commonly involved in wetland investigations, as are private consulting firms which have assessed environmental impacts. Private-interest groups and non-government organizations have contributed considerably to the body of literature. University research has also made a substantial impact on the state of the art, and includes several of the quantitative studies identified in Table 1. Unfortunately, there is a general lack of interagency coordination and integration in this field which contributes greatly to the incompleteness, inconsistency and duplication of the existing information.

The content of the literature focussing on land use change can be characterized

TABLE 1: QUANTITATIVE STUDIES: IMPACT OF LAND USE CHANGE ON WETLANDS*

Study Area Location and Reference	Study Area Size	Time Period	Land Use Change
Prairies			
.Black Soil Zone of the Prairie Provinces (Goodman and Pryor, 1972)	. 21 km^2 pristine wetland within 389 km^2	. 1800-1970	. 411 ha (19%) of wetland adversely affected by man-made alterations . 13% net loss of wetland area
Alberta			
.Alberta Aspen Parkland (Schick, 1972)	. 699 km^2	. 1900-1970	. 61% net loss of wetland area
.Battle River Basin (Ritter, 1979)	. 301 km^2 of wetland within 11 002 km^2	. 1800-1978	. 9% net loss of wetland habitat area
.South Saskatchewan River Basin (Schmitt, 1980)	. 45 km^2 of wetland within 19 601 km^2	. 1800-1979	. 21% gross loss of wet land habitat area . 7% net gain of wetland habitat area
Saskatchewan			
.Southern Saskatchewan (Millar, 1981)	. 82 km^2	. 1800-1980	. 2,346 (73%) wetland sites affected by transitory impacts . 881 (27%) wetland sites affected by permanent impacts
Manitoba			
.Newdale Plain (Adams and Gentle, 1978)	. 248 km^2	. 1964-1974	. 17 % of Wetlands altered by clearing or partial drainage . 7% of wetlands eradicated

* No quantitative reports were identified for British Columbia or the Atlantic provinces. Detailed summaries describing objectives, methodologies and results for each study are included in Appendix 1.

TABLE 1 CONT'D

Study Area Location and Reference	Study Area Size	Time Period	Land Use Change
.Minnedosa Pothole Region (Rakowski et al, 1974)	. 131 km^2	. 1964-1974	. 40% net loss of wetland area
.Minnedosa Pothole Region (Kiel et al, 1972)	. 131 km^2	. 1928-1964	. 26% net loss of wetland area . 60 (50%) potholes adversely affected by man-made alterations
Ontario			
.Southern Ontario (Cox 1972)	. 36 counties	. 1800-1950	. 12 000 km^2 (55%) loss of wetland area
.Southern Ontario (Snell, 1982)	. 38 counties	. 1800-1970	. 12 000 km^2 (70%) loss of wetland area
.Southern Ontario (Bardecki, 1981)	. area of 8 National Topographic Service map sheets	. 1966-1978	. 317 ha (1%) of wetland area drained
.Lake Ontario Marshes Toronto to Oshawa (Lemay, 1980)	. 374 ha of marsh	. 1931-1976	. 134 ha (44%) loss of marsh area
.Kawartha Lakes Marshland (Lewies and Dyke, 1973)	. 46 km^2 of marsh	. 1960-1969	. 915 ha (20%) loss of marsh area
.Point Pelee Marsh (Rutherford, 1979)	. 39 km^2 of marsh	. 1880-1975	. 28 km^2(71%) loss of marsh area
.Lake St. Clair Wetlands (McCullough, 1981)	. 35 km^2 of wetland	. 1965-1978	. 882 ha (25%) loss of wetland area
.Lake St. Clair Marshes (Rutherford, 1979)	. 173 km^2 of marsh	. 1915-1978	. 106 km^2(39%) loss of marsh area
.Lake Ontario shoreline wetlands - Niagara River to Prince Edward County (McCullough, 1981)	. 90 km^2 of wetland	. 1900-1978	. 42% loss of wetland area
Quebec - Ontario			
.St. Lawrence River - Cornwall to Matane (Le Groupe Dryade, 1982)	. 70 km^2 of wetland habitat	. 1945-1975	. 42% of wetland area converted

TABLE 2: WETLAND INVENTORIES, EVALUATIONS AND PRIORITY ASSESSMENTS RELATING TO LAND USE CHANGE

Project/Program	Agency	Areal Coverage	Status
National			
Development of "Wetlands of Canada" and "Distribution of Wetlands of Canada" maps for the National Atlas of Canada; and production of book, "Wetlands of Canada"	Canada Committee on Ecological Land Classification, National Wetland Working Group	All of Canada	Ongoing
Preparation of a map of Canadian peatlands and a description of existing inventories of peatlands	Dendron Resource Surveys Ltd., under contract to Peat Forum	All of Canada	Ongoing
Pacific			
"Wetland Classification System for the Cariboo Resource Management Region"	Runka, G.G., and T. Lewis for the Assessment and Planning Division, British Columbia Ministry of the Environment, Victoria, British Columbia	Cariboo-Chilcotin District, interior plateau of British Columbia	Completed (1981)
"Fraser River Estuary Study" (including six 1:25,000 habitat maps)	Surveys and Resource Mapping Branch, British Columbia Ministry of the Environment, Victoria, British Columbia	Fraser River estuary, British Columbia	Completed (1982)
"Estuary Habitat Mapping Inventory and Classification System"	Surveys and Resource Mapping Branch, British Columbia Ministry of the Environment, Victoria, British Columbia	Selected estuaries on the British Columbia coast	Manual completed (1982); mapping ongoing
"Priority Rating of Coastal Wetlands for British Columbia Coast"	Surveys and Resource Mapping Branch, British Columbia Ministry of the Environment, Victoria, British Columbia	Entire British Columbia coast	Completed (1982)
"Coastal Resources Folio"	Lands Directorate, Pacific and Yukon Region, Vancouver, British Columbia	East coast of Vancouver Island (Race Point to Hatch Point) and adjacent islands	Completed (1982)

TABLE 2 CONT'D

Project/Program	Agency	Areal Coverage	Status
"Documentation of Historical Changes to Fraser Estuary Marsh Habitat"	Westwater Research Centre, University of British Columbia, Vancouver, British Columbia	Fraser River estuary, British Columbia	Ongoing
Prairies			
"Migratory Bird Habitat Priorities - Prairie Provinces"	Canadian Wildlife Service, Western and Northern Region, Environment Canada, Edmonton, Alberta	Provinces of Alberta, Saskatchewan and Manitoba	Completed (1979)
"A Habitat Priority Evaluation of the Minnedosa District of Manitoba"	Canadian Wildlife Service, Western and Northern Region, Winnipeg, Manitoba	Minnedosa District, southwest Manitoba	Completed (1980)
"Cooperative Breeding Ground Surveys" (program includes habitat evaluation)	Canadian Wildlife Service, Prairie Migratory Bird Research Centre, Saskatoon, Saskatchewan	Sample transects across prairie provinces	Annual, ongoing
"Waterfowl Habitat Inventory"	Ducks Unlimited Canada, Ltd., Head Office, Winnipeg, Manitoba	Prairie parkland, and forest-edge regions	Ongoing
"Wetland Inventory and Reconnaissance"	Ducks Unlimited Canada, Ltd., Provincial and Regional Offices across Canada	Selected wetland areas across Canada	Ongoing
"Wetland Habitat Inventory"	Wildlife Branch, Saskatchewan Department of Tourism and Renewable Resources, Saskatoon, Saskatchewan	3 NTS map sheet areas in Saskatchewan: Kindersely (72N); North Battleford (73C); St. Walburg (73F)	Completed (1982)
"Wetland Inventory hecklist - Prairie Parkland"	Saskatchewan Wetlands Working Group, Saskatoon, Saskatchewan		System designed (1980)
Ontario			
"The Location and Ownership of Marshes on Lakes Erie and St. Clair"	Brobst, B.K., and M. J. Sharp for the University of Waterloo, Waterloo Ontario, and the Nature Conservancy of Canada, Toronto, Ontario	Lake Erie and St. Clair marshes	Completed (1978)
"Inventory of Lower Great Lakes Wetlands"	Canadian Wildlife Service, Ontario Region, Environment Canada, London, Ontario	Lake Erie and St. Clair shoreline	Completed (1978)

TABLE 2 CONT'D

Project/Program	Agency	Areal Coverage	Status
"An Evaluation System for Wetlands of Southern Ontario"	Canadian Wildlife Service, Ontario Region, Environment Canada, Ottawa, Ontario; Wildlife Branch, Ontario Ministry of Natural Resources, Toronto, Ontario; and Lands Directorate, Ontario Region, Burlington, Ontario	Wetlands south of the Precambrian Shield in Ontario	System designed (1982); field testing and revision ongoing
"A Wetland Evaluation System for Southern Ontario"	Ecologists Ltd., Kitchener, Ontario	Southern Ontario	System designed (1982) for program 25 listed above
"Marsh Inventory for Southwestern Ontario"	Dubsky, H.L., York University, Downsview, Ontario	Southwestern Ontario	Completed (1977)
"A Wetlands Evaluation Model for Southern Ontario"	Federation of Ontario Naturalists, Don Mills, Ontario	Applied in Kawartha Lakes study	System designed (1981) and field-tested by Canadian Wildlife Service
"An Inventory and Analysis of the Wetland Areas within the Kawartha Region"	Kawartha Region Conservation Authority, Fenelon Falls, Ontario	Wetlands within the Conservation Authority watershed	Completed (1981)
Wetland inventory and evaluation	Maitland Valley Conservation Authority, Exeter, Ontario	Wetlands within the Conservation Authority watershed	Ongoing
"Wetland Classification Maps for the Hudson Bay Lowland"	Ontario Centre for Remote Sensing, Ontario Ministry of Natural Resources, Toronto, Ontario	Ontario portion of Hudson Bay lowland	Ongoing
"Peat Resource Evaluation Program"	Ontario Geological Survey, Ontario Ministry of Natural Resources, Toronto, Ontario	Province of Ontario	Ongoing

TABLE 2 CONT'D

Project/Program	Agency	Areal Coverage	Status
Quebec			
Étude de faisabilité de la restauration d'une zone de marais intertidal dans la baie de Rivière-du-Loup"	Canadian Wildlife Service, Quebec Region, Environment Canada, Ste-Foy, Quebec	Rivière-du-Loup Bay	Scheduled to start in 1983
"Habitats proprices aux oiseaux migrateurs" (An inventory and classification of migratory bird habitat)	Le Groupe Dryade Ltée for the Canadian Wildlife Service, Quebec Region Environment Canada, Ste-Foy, Quebec	Shorelines of the Ottawa, Richelieu, and St. Lawrence Rivers, St. Lawrence estuary, north coast of the Gulf of St. Lawrence, Gaspé Peninsula, and Iles-de-la-Madeleine	Completed (1980)
"Localisation des endroits les plus frêquentés par les oiseaux le long du St-Laurent"	Canadian Wildlife Service, Quebec Region Environment Canada Ste-Foy, Quebec	Shoreline of the St. Lawrence	Completed (1983)
"Evaluation des superficies des tourbières du sud du Québec"	Hydro Quebec, Montreal, Quebec	South of the 50th degree of latitude, Quebec	Completed (1983)
"Identification of Potential Bio-energy Projects with Classification and Implementation Logistics"		Eastern Canada	Completed (1983)
Inventory of Peatlands of Quebec	Ministry of Natural Resources, Government of Quebec, Quebec, Quebec	Quebec	Ongoing
Atlantic			
"Wetlands, Peatlands Resources, New Brunswick"	Airphoto Analysis Associates Consultants Limited, for the New Brunswick Department of Natural Resources, Fredericton, New Brunswick	Province of New Brunswick	Completed (1975)

TABLE 2 CONT'D

Project/Program	Agency	Areal Coverage	Status
"Wetland Protection Mapping and Designation"	Canadian Wildlife Service, Atlantic Region, Environment Canada, Sackville, New Brunswick, in cooperation with Provincial Governments of New Brunswick, Prince Edward Island and Nova Scotia	Provinces of Nova Scotia, New Brunswick and Prince Edward Island	Ongoing, to be completed 1984
Classification and Ecology of Wetlands within Labrador	Lands Directorate, Dartmouth, Nova Scotia, and the Canadian Forestry Service, St. John's, Newfoundland, in cooperation with the Peat Forum	Labrador	Ongoing
"New Brunswick's Peat Resource Evaluation Program"	Mineral Development Branch, New Brunswick Department of Natural Resources, Fredericton, New Brunswick, in cooperation with the Federal Department of Regional Economic Expansion	Province of New Brunswick	Completed (1982)
"Peatland Inventory"	Newfoundland Department of Forest Resources and Lands, St. John's, Newfoundland	Province of Newfoundland (Island area)	Ongoing
Peatland Inventory of Nova Scotia	Nova Scotia Department of Mines, Halifax, Nova Scotia	Province of Nova Scotia	Ongoing
"Wetlands and Wildlife Management in the Shubenacadie-Stewiacke River Basin	O'Brien, M., and E. Hodgins, and the Wildlife Division, Department of Lands and Forests, Kentville, Nova Scotia, for the Shubenacadie-Stewiacke River Basin Board	Shubenacadie-Stewiacke River basin, Nova Scotia	Completed (1978)
Inventory of peat bogs in relation to their value in the measurement of acid rain loading	E. Gorham, University of Minnesota, Minnesota	Atlantic Region, as wells as eastern Canada and the North-eastern U.S.	Ongoing

according to the three major issues: wetland conversion, the nature of encroaching land uses, and the implications of wetland loss.

Only fifteen quantitative studies - reports which document the rate and/or extent of wetland conversion - are identified in this review for southern Canada. Detailed descriptions of these quantitative studies are provided in Appendix 1, and a summary of these studies is included in Table 1. Other reports allude to a change in wetland area, or submit generalized estimates of the extent of such change. Of the fifteen reports, seven are focussed on areas in Ontario, one in Quebec, and seven in the Prairie provinces. No quantitative reports were identified for British Columbia or the Atlantic provinces.

Measurements of wetland conversion are difficult to compare and assess, varying considerably according to such factors as location and area of coverage, data management requirements, the definition of "wetland", the nature of encroaching land uses, the methodology used, the duration of the study period, and weather conditions. However, the available data clearly indicate a declining trend in wetland area across southern Canada. Wetland conversion to date in selected areas in the prairie provinces ranges from 9 to 61% of the original area. Comprehensive surveys of southern Ontario identify losses of 55 to 70%, with localized studies measuring wetland conversion in the order of 1 to 2% per year. Approximately 42% of the wetlands studied along the St. Lawrence River were converted to other uses in the 30-year period preceding 1975 (Table 1).

Agriculture dominates the list of reported encroaching land uses. Detailed information is available concerning the economic, technological, and legislative factors related to agricultural conversion of wetlands in the Prairies and Ontario. While agriculture has a long history of extensive impact on wetlands, urbanization is also documented as a serious current threat to wetland integrity. The issue of changing land use on wetlands in coastal areas is particularly well documented. Development for energy-related and recreational land uses is receiving increasing attention because of their significant impact on the wetlands resource.

Recent emphasis has been placed on the loss of wetland natural values. The significance of wetlands as habitat for waterfowl, particularly for migratory birds, is the focus of major research efforts which continue to link changes in migratory bird population to wetland decline statistics, particularly in the prairie provinces. While these studies appear to be the most detailed and sophisticated of wetland land use change research, more recent documentation relates wetland area change to other intrinsic factors such as fish habitat, flood control, groundwater recharge, erosion bufferage, and water-quality maintenance. This reflects a growing recognition of the need to communicate the entire range of wetland functions in order that the integrity of these natural systems be respected.

In addition to the sources of information cited thus far, there are many documents which focus on planning and environmental impact assessment, and which include information on land use pressures on the

wetlands resource. For example, information regarding land uses on British Columbia estuaries is included in recent management proposals, and background reports. References to these reports are included in the Bibliography and Appendix 2. Impact assessments of major hydro-electric power developments across the country frequently describe changes to wetland areas. In Ontario, Environmentally Sensitive Area (ESA) reports have been completed for over twenty counties and regions. As well as detailed descriptions of wetlands, these accounts often include information concerning development threats. International Biological Program (IBP) reports serve a similar purpose for a limited number of sensitive areas across Canada, including wetlands. Although these documents are potentially valuable data sources, the majority of them are extremely localized in focus and of limited value to a national perspective.

Precise definition of the interrelationships between the various components of a wetland system and the functions they perform is one of the most pressing needs in wetland research. Quantitative information relating the capacity of wetlands to support various roles is lacking and is absolutely necessary for effective management of the resource. Without this knowledge, decisions regarding the extent and quality of wetlands that must be preserved in order to protect a particular function, are based on insufficient information and subject to critical error.

A recent project to assess the sensitivity of wetland ecosystems in the Beaufort Sea and Northwest Passage regions of northern Canada, particularly in terms of wildlife factors, has been initiated by the Lands Directorate and Canadian Wildlife Service of Environment Canada. Concepts developed for southern regions often have little applicability in these northern regions; however, we are only now recognizing that wetlands are sensitive to land use changes in all of Canada's diverse environments.

3.0 LAND USE CHANGE PRESSURES

3.1 AGRICULTURAL RECLAMATION

Historically, agricultural reclamation has been the major force behind wetland decline in Canada, accounting for widespread and significant encroachment on the wetlands resource base. Lakeshore wetlands, inland bogs, marshes, swamps, and the potholes of the Prairies, Ontario, and Quebec continue to be drained and cultivated for specialized market-gardening and the extension of row cropping and pasture. Across the country, peat is harvested from organic wetlands for horticultural application. Interior sedge meadows in British Columbia are used for grazing and for forage production. Extensive dikes on the Atlantic and Pacific coasts protect large expanses of silt beds from tidal inundation, thereby permitting crop production and grazing. The agricultural conversion of wetlands began with the arrival of the first settlers and continues to this day.

Wetlands were originally reclaimed for agriculture since they were viewed as potentially productive farmland. More recently, wetland drainage has often been due to the economic pressure to bring every available unit of land into production. Agricultural expansion onto marginal lands, including wetlands, has been encouraged by an increased demand for goods, ready markets, rising production costs and the attendant need to increase farm efficiency, as well as by government subsidies. In some cases, the development of prime agricultural land for other uses pushes farms onto the less productive marginal lands, including wet areas. In other cases, the growing demand for agricultural land and subsequent price or tax increases results in the improvement of existing resources including the drainage of wetlands, rather than the acquisition of more land. However, several major concerns have been raised across the nation regarding the agricultural use of wetlands: its value for crop production, the economic and environmental costs of drainage, and the related legislative provisions.

The agricultural use of wetlands has proven successful in some areas. Foodstuff production of national and regional significance has been based on wetlands, for example, in the fertile farmland of the Fraser Delta, British Columbia, and the Holland Marsh area of Ontario. But numerous reports detail drainage schemes which have resulted in limited agricultural benefit. Reed and Smith (1972) noted that many hectares of diked land remain idle in the Maritimes because of the limited agricultural value of reclaimed tidal marsh. In a study of sample drainage projects in Ontario, Found et al (1975) identified a significant number of projects with poor cost-benefit ratios. Other case studies (Day et al, 1976; Diebolt, 1981) reveal the failure of drainage to increase agricultural productivity as expected. Wetland clearing and drainage in the Prairies often results in increased soil salinization, which ultimately reduces crop success (Cowan, 1982).

In addition to the financial costs of wetland drainage, possible environmental costs include changes in groundwater levels, water quality, and the magnitude and timing of stream flow, often resulting in down-

stream flooding, reduced baseflows, and the loss of vegetation and wildlife habitat (Cowan, 1982; Day et al, 1976; Ontario Legislature Select Committee on Land Drainage, 1974; Ontario Ministry of Natural Resources, 1973; Reed and Smith, 1972; Ritter, 1979; Schmitt, 1980).

Provincial and federal legislative acts have been criticized for accelerating the drainage of wetlands for agricultural use, particularly through programs which include subsidies and cost-sharing agreements (Bardecki, 1981; Cowan, 1982; Day et al, 1976; Found et al, 1975; Reed and Smith, 1972; Reid and Keeping, 1979). Property-tax and quota-allotment systems also provide incentives for farmers to reclaim poorly drained lands. The major complaint, however, concerns the general lack of mandatory, comprehensive assessment of the cost-benefit or environmental impact associated with drainage projects (Bardecki, 1981; Reid and Keeping, 1979; Weiss, 1982). Present procedures for obtaining approval and assistance for drain construction do not adequately take into consideration the uses and values of wetlands, and the associated implications of drainage.

British Columbia: The Fraser Delta (Figure 1) is one of the most productive areas in Canada for livestock, forage crops, fruits, vegetables, and ornamental horticulture (British Columbia Land Resources Steering Committee, 1978). It is in fact recognized as one of the most important vegetable-producing locations in the nation (Simpson-Lewis et al, 1979). Although an extensive area of delta and estuary has been drained for agricultural production, the construction of the continuous dike systems was due primarily to the devastating impact of the major floods of 1894 and 1948 on the Lower Fraser River lowlands. Historical and current estimates of the extent of the diked areas are available; however, from these estimates, the proportion of the area in agricultural use, and therefore an indication of the significance of its impact on wetland conversion in the Lower Fraser Valley, could not be ascertained.

Diking programs which followed the flood of 1894 have had the greatest impact on the Fraser delta (Fraser River Estuary Study Steering Committee, 1978a). The 1978 Fraser River Estuary Study estimated that these early diking programs had a major effect on the conversion of the original estuarine wetlands. It is also recognized that in estuarine wetlands, particularly intertidal and brackish marshes, there is a slow wetland accretion process which may be accelerated by training walls and dredging (G. Howell Jones, pers. comm.). A present dike upgrading and reconstruction program will continue to have an effect on the Fraser River marsh communities. At the present time, urban and industrial developments in the Fraser Delta are a much greater threat than agricultural reclamation. Such conversion is progressive, exclusive and particularly destructive to wildlife habitat. Further details regarding land-use conflict in the Fraser Delta area are provided in the "Urban and Industrial Development" section of this report.

The extensive organic wetlands of the Cariboo-Chilcotin region of the Interior Plateau (Figure 1) are undergoing increasing pressure for conversion to agricultural use, which is considerable

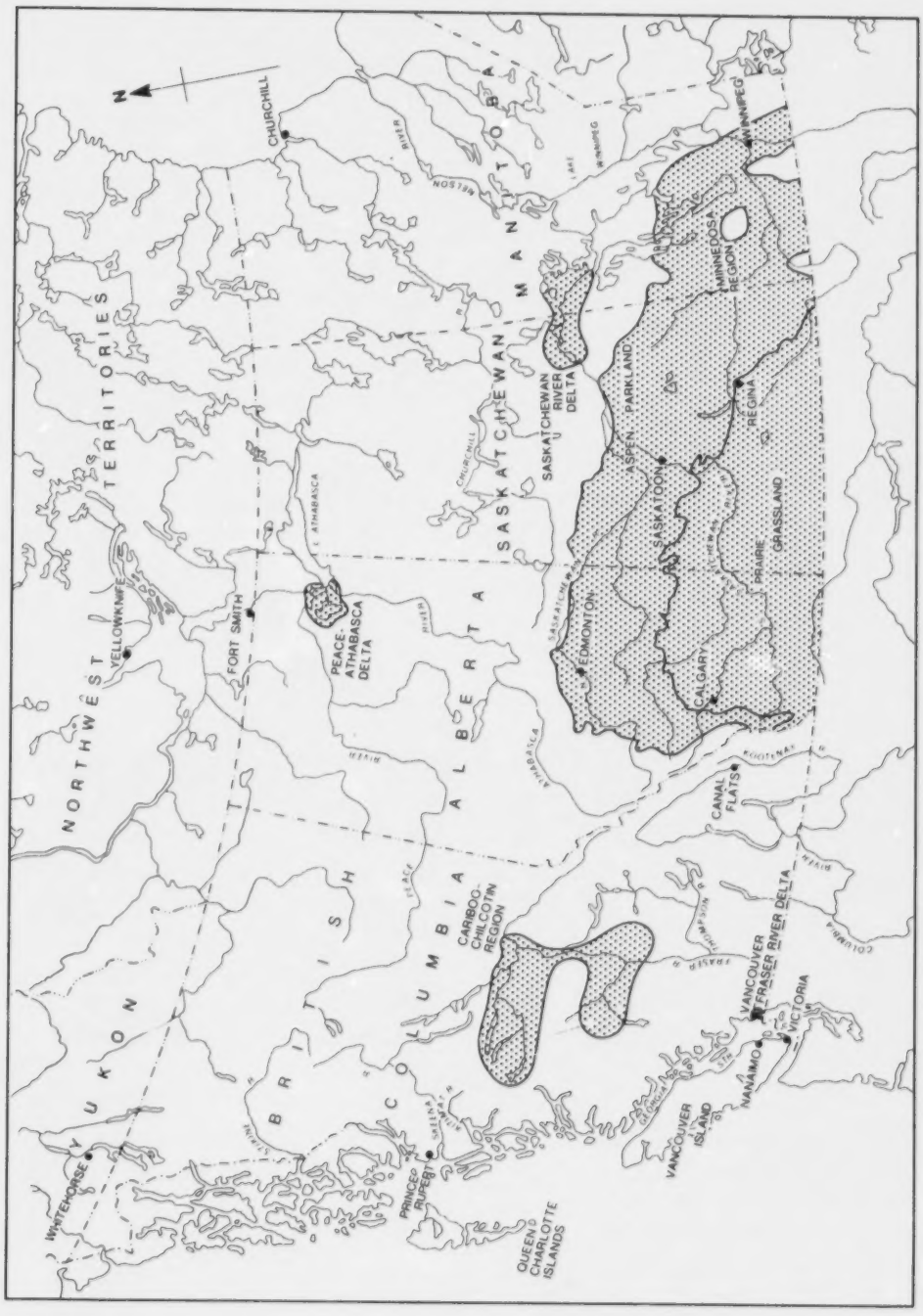

FIGURE 1: AREAS OF INTEREST: LAND USE CHANGE ON WETLANDS, WESTERN CANADA

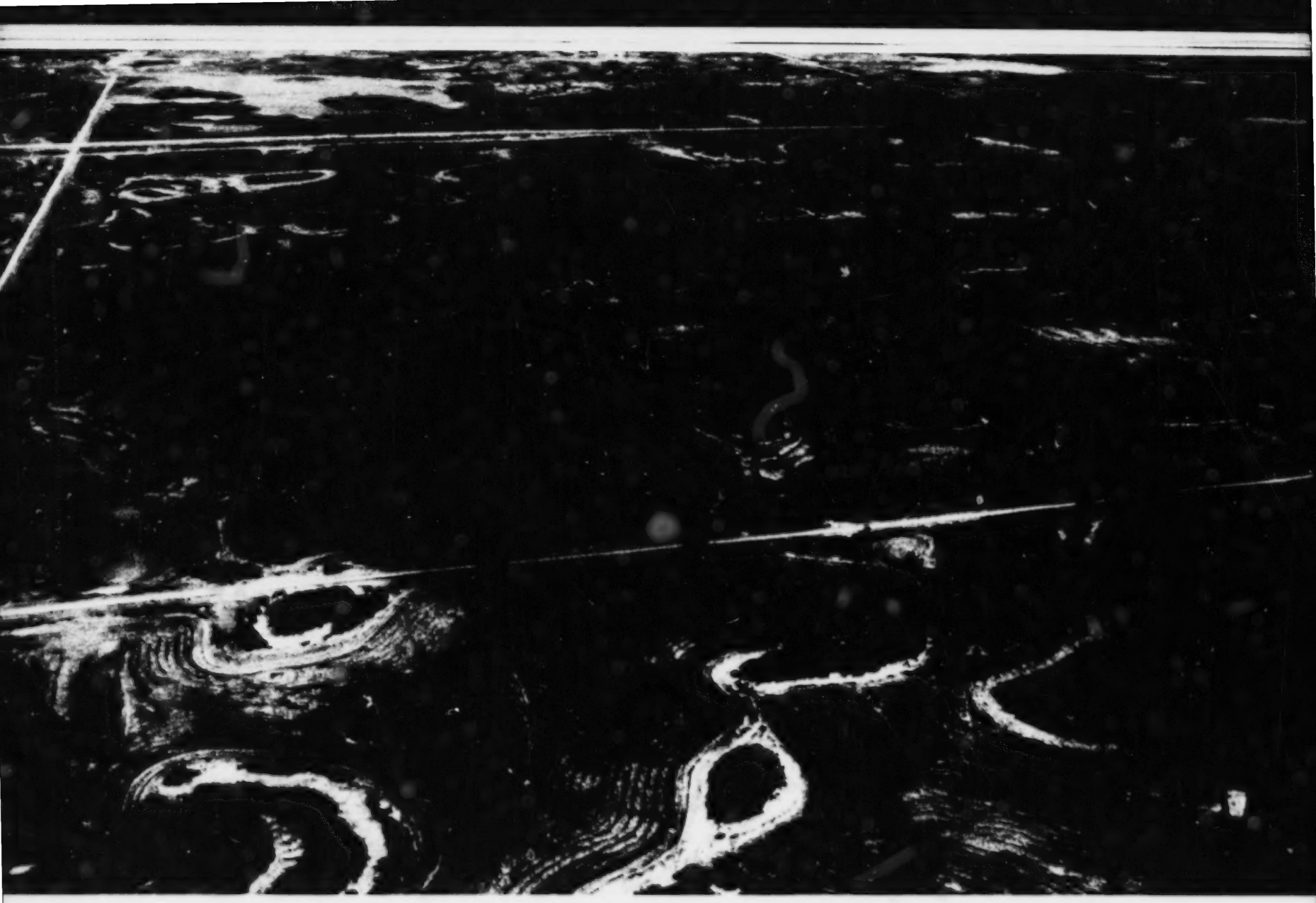

Plate 2: Agricultural reclamation has been the major force behind wetland decline, being of particular concern in the prairie pothole region of western Canada.

concern to the resource managers of that region (Moon and Selby, 1982). The Cariboo-Chilcotin region is regarded as an essential component of the natural rangeland of the province (Smith, in British Columbia Department of Agriculture, 1975). Included are wetland sedge meadows, which are of major importance to many ranching operations for hay production or direct fall and winter grazing.

Many of the wetlands are still being used in their native state or with limited water-control improvements. In recent years, there has been more active management of the wetlands through water control, conversion to non-native species, and fertilization (Van Ryswyk, in British Columbia Department of Agriculture, 1975). These practices have resulted in an improvement of the forage supply and a more stable livestock industry. The trend to intensify wetland use is expected to continue with government financial assistance. Little is known about the impact of agriculture on other wetland functions and values in this region. Inventory and classification of the Cariboo-Chilcotin wetlands has been initiated by the Canadian Wildlife Service and trend analysis research using air photos is being considered (S. Boyd, pers. comm.). The B.C. Research Council is currently under contract to Environment Canada to investigate LANDSAT thematic mapper wetland monitoring procedures.

Western Region: The prairie provinces of Alberta, Manitoba and Saskatchewan contain the largest single expanse of arable land in Canada, renowned for the production of wheat, mixed grain, and beef (Simpson-Lewis et al, 1979). Located in the southern third of the prairie provinces, this fertile area is characterized by an abundance of shallow wetlands called "sloughs" or "potholes", varying in size from fractions of a hectare to several hundred hectares. Referred to as "the prairie pothole region", the area closely coincides with the prairie grassland and aspen parkland regions of western Canada (Figure 1).

This region is also a vital component of Canada's wildlife heritage. The high density of wetlands provides habitat for raising approximately one-half of the population of North American waterfowl as well as many other migratory birds (D. Gillespie, pers. comm.). Migratory birds, especially waterfowl, are dependent on wetlands for food, nesting and brood habitat, protective cover and staging areas.

The intense conflict over prairie wetlands for wildlife habitat versus agricultural use is the most extensively documented of the wetland issues in Canada. Losses of wetland habitat to agriculture over the past century have been progressive and severe, occurring in virtually all parts of the Prairies. In addition to the direct loss of wetland basins through artificial drainage, agricultural intensification often results in the deterioration of marsh-edge vegetation - the essential upland component of waterfowl habitat. In total, approximately 1.2 million ha of wetland habitat have been converted to agricultural use in the prairie provinces (Bellrose, in Simpson-Lewis et al, 1979).

From the farmers' perspective, crop depredation by waterfowl is a serious problem: a

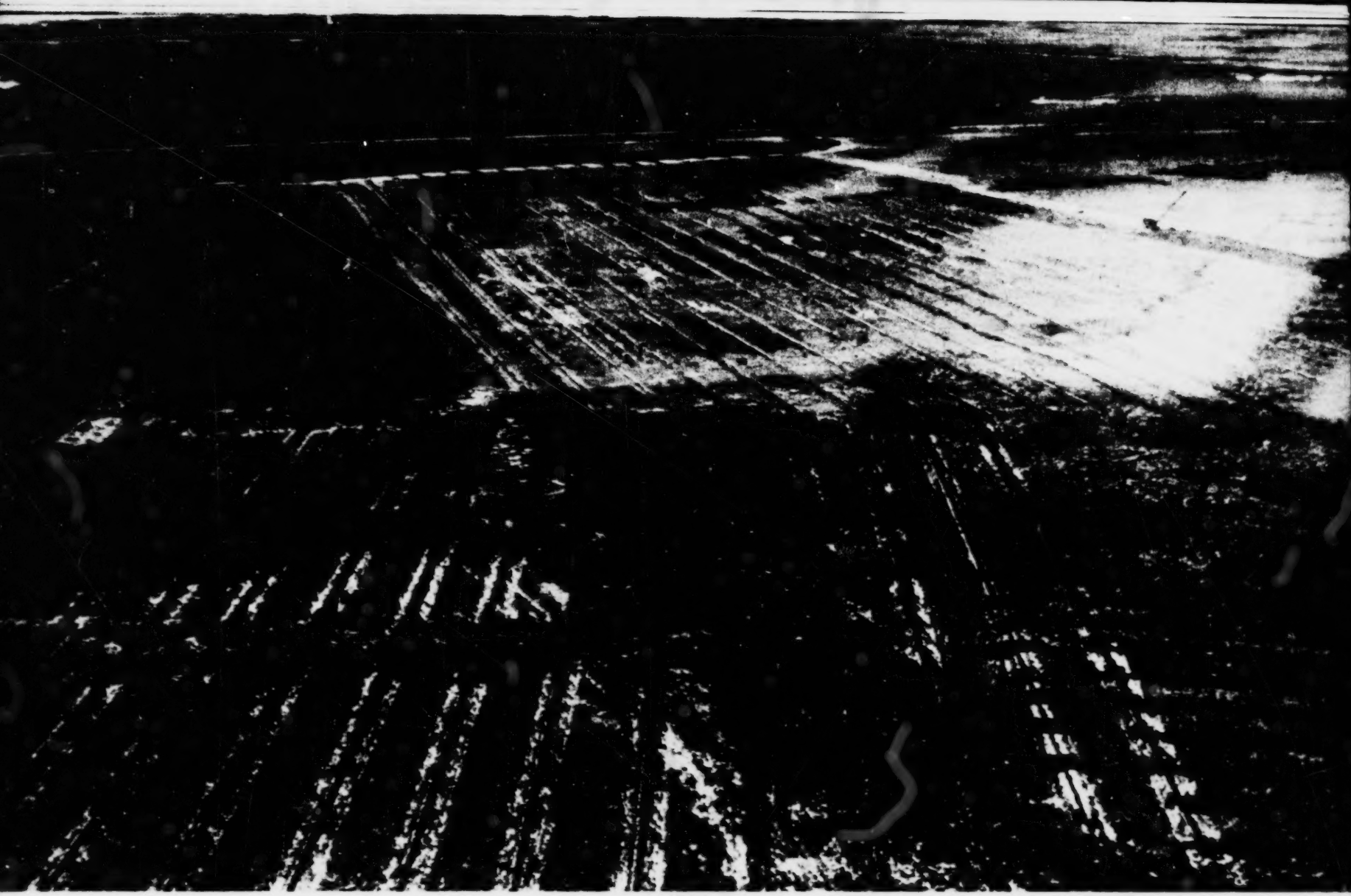

Plate 3: Drainage of marsh areas for agricultural use continues to threaten a dwindling wetlands resource.

conservative estimate of loss through trampling and consumption of grain is about $16-24 million annually (W.C. Craddock, pers. comm.).

Studies of land use change in western Canada have been directed primarily to areas which are of particular value to migratory birds. Agricultural conversion due to drainage, infilling, and cultivation has been cited as the overwhelming factor in wetland decline in all of these studies. Investigating the Minnedosa Region of southwestern Manitoba (Figure 1), Rakowski et al (1974) reported a 57% decline in total wetland area during the period 1929-1974, and predicted a continuing downward trend. Adams and Gentle (1978) concluded that 11% of the basins they studied in the Minnedosa region had been partly drained and 6% had been altered by clearing or filling. Focussing on a study area within the Alberta parkland region (Figure 1), Schick (1972) found that only 39% of the original pre-settlement wetland area remained. Millar (1981) investigated wetlands on sample transects located in southern Saskatchewan and found that, by 1979, 84% had in some way been affected by human activities. Nineteen percent of the original wetland area and 9% of the ponds in the Prairies' black-soil zone, located in the northern section of the parkland region (Figure 1), were found to be adverseley affected by man's activity by Goodman and Pryor (1972). All studies indicate continuing decline in wetland area.

Discussions on the influence of drought on wetlands pervades the prairie research. Seasonal fluctuations in precipitation, characterized by prolonged periods of drought, are a common and integral part of the prairie environment. Natural drawdown stimulates vegetative growth in wetlands with an explosive nutrient release when reflooding occurs. However, drought also encourages the conversion of wetlands to agriculture by exposing dry basins which are potentially arable. Once the drought is over, these basins which have been cultivated are often drained to maintain yields. Hence, drought sets the stage for the destruction of potholes (Mann, 1975).

Various researchers have indicated significant cumulative losses caused by the drainage of small potholes, i.e., those less than 2-4 ha in size (A. Ritter and K. Schmitt, pers. comm.; J.B. Millar and G.D. Adams, pers. comm.). Goodman and Pryor (1972) observed that drainage was primarily the work of landowners or small drainage projects, and that provincial water resource developments or major drainage projects accounted for only 20% of the total conversions.

Millar (1981) related the quality and losses of wetland habitat to surficial geology, and concluded that the highest quality of wetland habitat conditions occur on knob and kettle moraine and ground moraine, the latter being in the greatest jeopardy. Goodman and Pryor (1972) identified a significantly higher rate of wetland loss on Canada Land Inventory (CLI) prime agricultural classes 1 to 4 lands, than on poorer class 5 to 7 lands. It was speculated that the CLI Capability for Agriculture classification represented a mapping of the potential threat of loss to waterfowl habitat.

The widespread reduction of habitat due to changing land use has been cited as a major factor in the diminishing annual production

of waterfowl, particularly since 1960 (Mattson et al, 1978; Rakowski, 1980). Unfortunately, other ramifications of wetland drainage have been overshadowed in the prairie wetland literature by an emphasis on loss of habitat value. For example, it is seldom mentioned that the loss of water storage capacity (due to declining wetland area) increases the potential for flooding. However, efforts to protect wetlands for habitat use will inevitably result in additional social and environmental benefits. The Canadian Wildlife Service and Ducks Unlimited (Canada) Ltd. have extensive, continuing programs of habitat reconnaissance across the prairie region, involving field assessment of man-made impacts on wetlands, as well as the monitoring of waterfowl populations. These two agencies maintain the largest western wetland data sets, and share responsibility for waterfowl management.

Ontario Region: A recent Environment Canada study (Snell, 1982) estimates that over one million hectares (or 70%) of southern Ontario's pre-settlement wetland area have been converted to other uses. Agricultural reclamation, and specifically drainage, is identified as the major factor in that decline (Bardecki, 1981; Reid and Keeping, 1979; Found et al, 1975; Laidlaw, 1978).

Drainage activity varies in intensity but is widespread across southern Ontario, as are the farmlands, which are major producers of vegetables, fruit, specialty field crops, livestock, and poultry. This activity includes clearing and infilling of wetlands for cultivation, dredging for farm ponds, and diking of shoreline marshes for pasture and croplands. Having started in the mid-1800's, drainage is now a common activity on much of the province's farmlands. Evidence of continuing wetland drainage is provided by Bardecki (1981), whose study of eight randomly selected areas across southern Ontario concludes that 85% of the area converted in the period 1966-70 to 1978 is attributable to agricultural drainage.

Other studies of wetland decline have focussed on the marsh areas of shorelines. Lemay (1980) studied the Lake Ontario shoreline between Toronto and Oshawa and noted a 22% decrease in marsh area from 1860 to 1931, largely the result of agricultural development. Since that time, agriculture has accounted for only 3.6% of reclaimed marsh. Changes in the Point Pelee, Lake Erie, and Lake St. Clair marshes have been measured and evaluated by Rutherford (1979): it was found that the area of Point Pelee Marsh declined by 71%, from 3 878 ha in 1880 to 1 126 ha in the mid-1970's; the Lake St. Clair marshes experienced a loss of 39%, from 17 303 ha in 1915 to 6 684 ha in the mid-1970's. Agricultural land drainage was found to be by far the most significant factor in the decline of these wetlands, especially in the late 1800's. McCullough (1981) noted continued activity in the Lake St. Clair area, providing evidence that agriculture accounted for 91% of the wetland area loss on the Lake St. Clair shoreline between 1965 and 1978.

Concern has been expressed regarding the continued, small-scale drainage by agricultural landowners, resulting in a substantial cumulative effect across southern Ontario (Found et al, 1975; R. Reid, pers. comm.; M.J. Bardecki, pers. comm.). Despite declining drainage activity

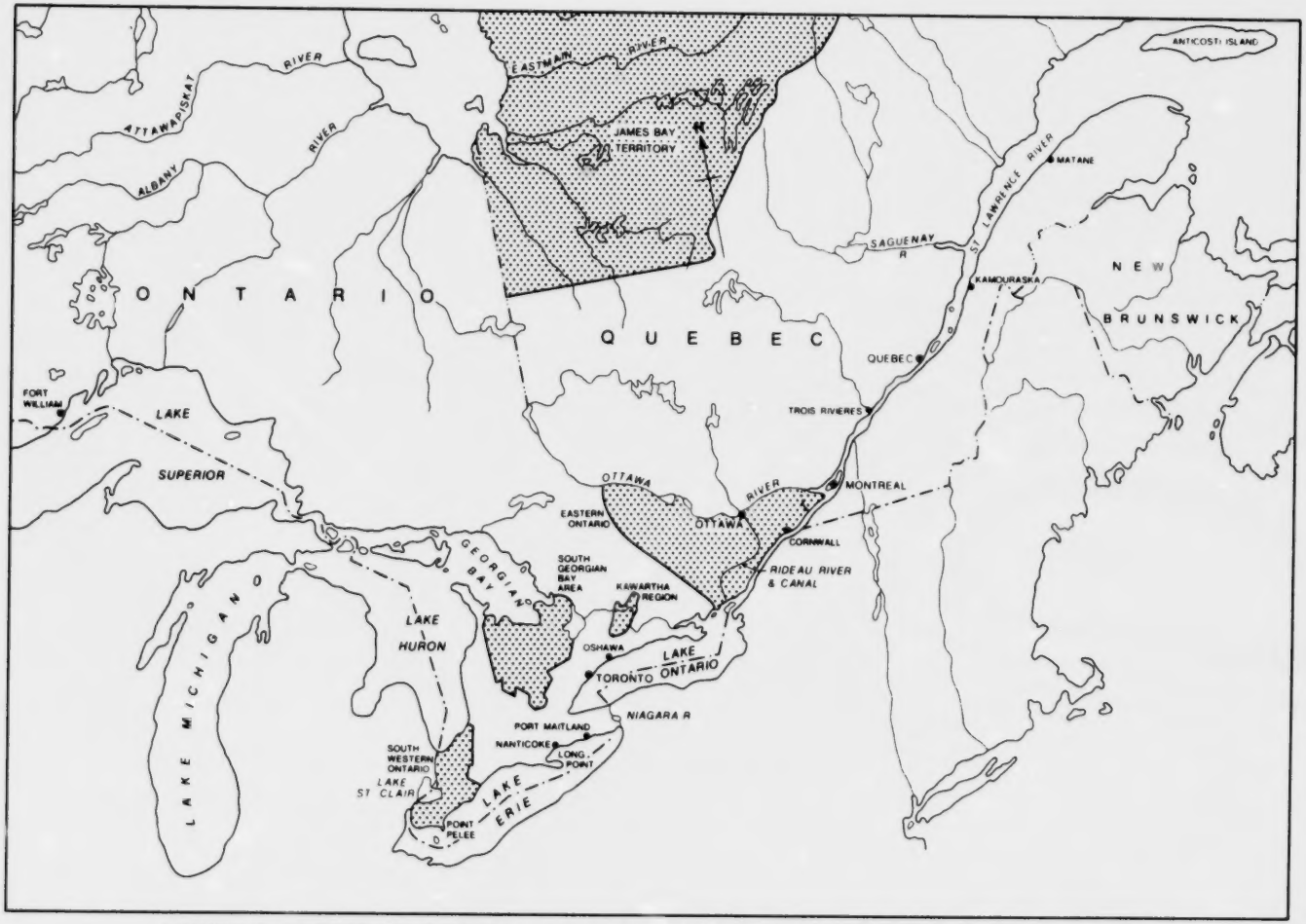

FIGURE 2: AREAS OF INTEREST: LAND USE CHANGE ON WETLANDS, ONTARIO AND QUEBEC

in some areas, and in view of the magnitude of funding allocated to drain reconstruction, impacts of drainage on wetlands are of major importance in terms of Ontario's dwindling wetland resource base. Although the impact on waterfowl is emphasized, the Ontario literature does reflect a wider range of concerns, including impacts on hydrological functions, fisheries, and a variety of wildlife and vegetation species.

There are three distinct areas of drainage activity in southern Ontario which are treated in the literature: southwestern Ontario, eastern Ontario, and the area south of Georgian Bay (Figure 2). The counties of Essex, Kent, and Lambton in southwestern Ontario represent an area of early and intense drainage activity (Bardecki, 1981). A valuable vegetable-producing area, this portion of southwestern Ontario continues to be the focus of drainage expenditures (Bardecki, 1981; Found et al, 1975). This is of major concern considering that to-date, these three counties have lost 95, 93 and 81% respectively of their original wetland area (Snell, 1982). The few remaining wetlands are of critical value to the migrating waterfowl, and represent one of the most important staging areas in southern Ontario (McCullough, 1981). Chuba (1977) notes the important role of wetlands as flood buffers, absorbing and storing large amounts of water, and as erosion barriers, providing shoreline protection against wave energy from the adjacent Lakes St. Clair and Erie.

Eastern Ontario is the second major area of drainage activity (Bardecki, 1981; Found et al; 1975; Reid and Keeping, 1979). The area to the east, including portions of Renfrew and Frontenac counties, has experienced recent drainage activity, and pressures are expected to remain high. It is estimated that 61-80% of wetlands have been converted to other uses in the areas of these counties south of the Canadian Shield (Snell, 1982). At present, there is concern about the remaining wetlands in eastern Ontario because of federal-provincial economic development programs, including a multi-million-dollar program for the subsidization of field drainage.

The area south of Georgian Bay is undergoing an increasing amount of drainage (M.J. Bardecki, pers. comm; R. Reid, pers. comm.). Pressure for wetland conversion is growing in Grey, Wellington, Dufferin, and Simcoe counties, all noted for their concentrations of remaining wetlands (Snell, 1982). Fears have been expressed regarding potential land-use conflicts (Whitney et al, 1972), especially since the wetlands in this region are of considerable hydrological significance. Since the area contains the headwaters of several major river systems; extensive drainage could result in widely fluctuating yearly flows and downstream flooding in heavily populated areas. The impact of drainage on the region's fisheries and wildlife resources is also under examination (Whitney et al, 1972).

The vast market gardens of the Holland Marsh are located in the south Georgian Bay area, about 40 km north of Metropolitan Toronto. The Marsh is an example of on-site agricultural use of a peatland area. In 1976, the drained, cultivated area of the Holland Marsh measured about 2 800 ha in size - 11 km in length and up to 3 km in width. Drainage of a further 5 200 ha of adjacent

wetlands was also initiated in 1976 (Walker, 1976).

Recognizing the importance of the remaining wetland areas in southern Ontario, the Canadian Wildlife Service and Lands Directorate of Environment Canada, with the Ontario Ministry of Natural Resources, are currently field-testing and revising a wetland inventory and evaluation system (Table 2). The evaluation system is scheduled to be finalized in 1983, but its application to the study of Southern Ontario wetlands has not yet been scheduled.

Quebec: In the St. Lawrence estuary, 32% of the tidal marsh has been reclaimed for agricultural use (Reed and Smith, 1972). Along the south shore of the St. Lawrence, 2 110 ha of tidal marsh remain, with an additional 1 000 ha reclaimed for agricultural use (Reed and Morison, 1971, in Arsenault, 1974). The remaining estuarine wetlands may be subject to considerable pressure for land-use change in the future. As the potential for agricultural expansion is primarily within the diking of tidal marshes, farmers along the south shore of the St. Lawrence continue to petition both the federal and provincial governments for structures to reclaim the coastal alluvial deposits for cropland. The most ambitious of the reclamation project proposals suggests that approximately 160 000 ha of tidal marsh in the Kamouraska Bay be diked for cultivation. However, cost-benefit analyses in the early 1970's indicated that reclamation on the St. Lawrence Estuary south shore was not economically feasible (Arsenault, 1974). Indeed, Reed and Smith (1972) noted that some dikelands on the estuary were idle, and the active areas clearly had low yields.

Atlantic Region: This region has a long history of agricultural reclamation of tidal salt marshes. Approximately 65% of maritime wetlands remain diked for agriculture. Hirvonen (1982) estimates that 11 600 ha of salt marsh remain in Nova Scotia, or roughly one-third of the marsh area of pre-settlement days. Gartley (1982) calculates that there are over 11 000 ha of agricultural dikelands and more than 3 000 ha of non-agricultural dikelands in New Brunswick. Agricultural use of salt marshes appears to be of no significance in Prince Edward Island. Substantial drainage has also occurred on four major river floodplains of Nova Scotia: the Cornwallis, Annapolis, Musquodoboit, and Shubenacadie rivers (Figure 3) which comprise the principal agricultural area of that province (F. Payne, pers. comm.). Information concerning the Annapolis Valley is reported in a tidal-power development proposal. An inventory of the Shubenacadie - Stewiacke Valley indicates concern for land use conflict there (O'Brien and Hudgins, 1978). However, existing sources provide little information on the use of inland wetlands in the Atlantic provinces.

Numerous reports describe the history of salt marsh reclamation for agriculture in the Tantramar area. Straddling the Nova Scotia-New Brunswick boundary on the Chignecto Isthmus at the head of the Bay of Fundy, Tantramar forms the largest single block of marshland in the Maritimes (Figure 3). This marsh contains some of the most productive waterfowl habitat in eastern Canada (Jackson and Maxwell, 1971). The Bay of Fundy is also of international importance

FIGURE 3: AREAS OF INTEREST: LAND USE CHANGE ON WETLANDS, ATLANTIC PROVINCES

for seabird and shorebird species (Pearce and Smith, 1974).

In 1672, Tantramar's first settlers initiated an extensive diking system to prevent tidal penetration of the marshes. By 1920, 80% of the Tantramar marsh was cultivated for hay and used for grazing, which severely limited waterfowl and wildlife habitat (Henderson, 1982a). After the 1920's, the prosperity of the area declined drastically and the dikes fell into disrepair. Gartley (1982) and Reed and Smith (1972) have reported a resurgence in Tantramar agriculture, which is mostly the result of land use intensification as opposed to an increase in cultivated area. A federal government study (Jackson and Maxwell, 1971) concluded that further investment in the Tantramar area would be uneconomic, given current conditions.

The decline of agricultural pressure on the marshlands has somewhat eased the conflict between human activity and wildlife in the Tantramar. Furthermore, concern for the effective long-term management of competing interests in the Tantramar has been acknowledged by the Canadian Wildlife Service and Lands Directorate of Environment Canada, and quantitative analyses of past and present land use trends have been proposed. (A.S. Smith, pers. comm.; Hirvonen, 1982).

The history of the reclamation of Annapolis Valley tidal marshlands (Figure 3) parallels the development of Tantramar in that the 1800's was a time of rapid agricultural expansion, followed by a decline in the early 1900's. The potential for agricultural use of the Annapolis marshlands was restored in the 1960's with the construction of a protective barrage near the river mouth. The barrage prevents tidal inundation for approximately 35 km of the Annapolis River estuary, protecting 1 545 ha of marshland for agricultural use. There is a current trend towards more intensive cultivation of the area (Martec Limited, 1980).

3.2 URBAN AND INDUSTRIAL DEVELOPMENT

Urban and industrial development are playing a more prominent role in wetland decline. Wetlands across Canada are developed for harbour facilities, manufacturing plants, warehouses, roads, airports, housing developments, utility rights-of-way, and shopping centres. Since 1950, increasing pressures for the dredging, draining and filling of wetlands for these developments have resulted in a severely reduced wetland base.

Warren and Rump (1981) provide data on the nature and extent of wetlands converted to urban uses for 80 major Canadian cities between 1966 and 1976. A total of 10 707 ha of land identified by the Canada Land Inventory as class 1 to 3 prime waterfowl habitat were converted to urban uses from 1966 to 1976. Of these converted lands, 554 ha were classified as swamps, bogs, or marsh and the remainder were generally poorly drained habitats. Wetlands near cities are significant since they represent a valuable conservation and recreational resource to 55 percent of Canada's population living in these urban centres. These wetlands are under the greatest direct pressure for conflicting uses (Rubec, 1980). Details concerning urban pressures on inland wetlands are lacking, except for the shorelines of the St. Lawrence River, lower

Great Lakes, and eastern and western coastal areas.

Central Canada (Ontario and Quebec): In their natural state, wetlands along the shorelines of the southern Great Lakes are valuable staging areas for migratory waterfowl. They also provide habitat for other resident and migratory birds, mammals, reptiles and amphibians, and provide spawning areas for a variety of fish species (McCullough, 1981). Wetlands act as a protective buffer against shore erosion and offer a variety of recreational opportunities. But historically, these shorelines have been meccas for urban growth: major centres have been established adjacent to the natural harbours, and today are integral links to the St. Lawrence Seaway shipping system.

Lake Ontario has suffered the most rapid and severe losses of wetlands due to urban and industrial expansion. McCullough (1981) estimated a cumulative loss of 42% of Lake Ontario's shoreline wetlands, primarily due to urbanization. The most significant impacts have occurred along the heavily populated western shore, from the Niagara River to the Oshawa area (Figure 2) where 80% (3 200 ha) of the wetlands have been destroyed or degraded because of man's activities (McCullough, 1981). Warren and Rump (1981), report that at least 323 ha of prime waterfowl habitat were converted to urban uses in Ontario between 1966 and 1976. A second major study by Lemay (1980) concludes that industries and harbours occupied the greatest area of reclaimed marsh on the Lake Ontario shoreline in 1976, followed by urban utilities and residential activities. Lemay also identified two distinct types of land use change that have eliminated waterfront marshes: the extensive dredging and filling for harbours and other large-scale industrial projects, and small-scale, incremental in-filling of marshes.

Development is again cited as a major agent in wetland decline on Lake Ontario by Houser (1979), Laidlaw (1978), and Reid and Keeping (1979). Laidlaw (1978) reported that no natural harbour along Lake Ontario remains unexploited by port facilities. Proposals for harbour expansion continue to threaten substantial waterfront wetlands, such as the Oshawa Second Marsh located 60 km east of Toronto. Several interest groups there, however, are opposing plans for a deep-harbour facility on the grounds that the Second Marsh is a natural area of national significance.

The marshes at the mouth of the Grand River near Port Maitland (Figure 2) constitute one of the most important wetland areas remaining on the eastern part of Lake Erie. Here, too, proposals for port facilitities and a bulk-handling terminal threaten its existence. McCullough (1981) noted that wetlands in the Point Pelee area of Lake Erie had experienced major alterations from agricultural drainage. The development of an industrial complex at Nanticoke (Figure 2), and associatiated urban expansion will increase the potential for environmental impact and resource-use conflicts on the Lake Erie shoreline (Nelson et al, 1980).

The northern shoreline of the St. Lawrence River is another area of urban and industrial development, particularly in a few major port centres; however, information on wetland conversion in this area is limited.

In 1981, the Canadian Wildlife Service sponsored a study by Groupe Dryade Lteē of historical trends in wetland areas along the St. Lawrence River, in response to concern for the decline of important migratory bird habitat. Analysis of shoreline aerial photographs between Cornwall, Ontario, and Matane, Quebec, (Figure 2) indicated losses of wetland habitat totalling more than 3 600 ha between 1945 and 1976. More than 75% of this area had been modified from 1945 to 1960 by the urban centres of Montreal, Trois-Rivieres, and Quebec City. Residential construction, harbour dredging, public utilities, and industrial expansion were recognized as the primary land uses encroaching on wetlands. Although the absolute rate of land use change appears to be declining, the pressures are significant in the context of the reduced resource base.

Atlantic and Pacific Coastal Regions: The resources of the Atlantic and Pacific coastal zones of Canada are also under pressure to accommodate urban and industrial development. Planning authorities are concerned about the encroachment on coastal salt marshes and deltaic freshwater marshes, and the impact on fish and wildlife resources. These wetlands are essential to the life cycles of many finfish and shellfish species, particularly salmonids. Estuarine salt marshes are a major habitat for migrating waterfowl, for shorebirds and for various marine mammals.

In the British Columbia coastal zone, urban population and development is concentrated in the Strait of Georgia region, which includes the southern mainland and southeast coast of Vancouver Island. Wetland conversion in the Strait is mainly related to the expansion of shipping facilities, and the impact of log handling, storage, and boom assembly on the ecosystem.

Urban growth in the Strait of Georgia and the mouth of the Fraser River is concentrated at Vancouver, the focal point of Canadian trade with the Pacific Rim and the western terminus of continental transportation networks.

The Fraser River has the most valuable estuary in southern British Columbia: it accommodates the largest salmon runs in the world; it is home for the largest population of wintering waterfowl in Canada; and is the most important stopping point for migrating birds on the Pacific flyway (Cameron and Obee, 1981). However, over the last century, vital marsh habitat has been lost to major dyking schemes for flood control, landfills for industrial and residential development, and extensive dredging to deepen the channel for shipping. As a result, remaining fish and wildlife habitats are greatly affected by log-storage and sorting systems (Cameron and Obee, 1981).

A study of the southwestern Fraser River lowland by North et al (1979) revealed the only remnants of the original vegetation in a natural state are several particularly large bogs and marshes. Reliable estimates on the magnitude of modifications to these ecosystems are expected in 1983 (G. Howell-Jones, pers. comm.).

Substantial research has been undertaken to develop a management program for the estuary, and conservation measures (from protective designations to outright

Plate 4: Wetlands of southern Canada are under increasing pressure for conversion to urban and industrial land uses.

purchases) are ongoing (Cameron and Obee, 1981). Meanwhile, population growth, industrial expansion, and major developments such as a proposed airport expansion and an extension of a coal-handling facility, continue to threaten the integrity of the remaining resource.

North of the Strait of Georgia, the effect of development has been relatively minimal. Increasing pressure is anticipated, however, due to greater requirements for log storage and movement, as well as the construction of port facilities for the transportation of interior coal and gas. Prince Rupert, which is the major centre on the northern coast, is adjacent to the Skeena River estuary: this estuary, and the Kitimat River estuary to the south (Figure 1), are focal points for development in the north. Factors such as relative proximity to coal and gas fields, established port facitilies, and abundant hydro power, encourage further industrial development. At present, a major port expansion and a bulk loading terminal are under construction at Prince Rupert.

Accurate measurements of wetland conversions are only available for the ten or so estuaries mapped by the Surveys and Mapping Branch, British Columbia Ministry of the Environment. The same branch, through its Fraser River Estuary Study habitat mapping (Table 2), provides a basis for monitoring land-use change on wetlands. Maps of other estuaries, incorporating a similar class ification system, could be used in the same manner (G. Howell Jones, pers. comm.). In 1981, the Westwater Research Centre, affiliated with the University of British Columbia, also initiated a project to document historical changes in the Fraser River estuary marsh habitat. This potentially valuable research was suspended in 1982.

Environment Canada and the Canada Centre for Remote Sensing are jointly investigating the present and future role of high-resolution satellite imagery in monitoring wetland vegetation in the Fraser River estuary. Results to-date indicate a high level of accuracy with the use of LANDSAT multi-spectral scanner data and the simulated thematic mapper data when tied to ground truthing (Tomlins and Thomson, 1981). An operational evaluation of LANDSAT-4 data is under way (B.C. Research, 1982).

Although urban and industrial pressures on the wetlands of the east coast have not been as severe as those on the Strait of Georgia, development has resulted in significant changes to wetlands (Henderson, 1982b). Reed and Smith (1972) noted the predominant influence of agricultural use on wetlands and, to a lesser extent, the effect of urban and industrial development on the declining salt-marsh area.

Maritime coastal areas appear to be on the verge of undergoing greater pressure from large-scale development projects. One current issue, as indicated by the local media and by correspondence between local government departments, is that of the estuarine salt marshes near Halifax and Saint John. An example is the Chezzetcook Inlet area, north of Halifax (Figure 3): it is one of two remaining large salt march estuaries on Nova Scotia's eastern shore, providing an important habitat for a variety of aquatic and wildlife populations. Proposed construction of a highway through the Inlet has

prompted considerable opposition since the infilling required for a causeway would result in the conversion of an extensive area of salt marsh and fish habitat. Opposing parties maintain that the highway route is environmentally unacceptable regardless of mitigative measures, as yet, government authorities have not made a final decision. Cole Harbour (Figure 3), one of the most productive salt marshes on Nova Scotia's eastern shore, is also under pressure from the expanding Halifax-Dartmouth urban area (A. Green, pers. comm.).

Saint John is the largest industrial centre in New Brunswick and has the only international port on the Bay of Fundy. Because its role in international trade has expanded in recent years, expansion of port facilities will be required (G. Lindsay, pers. comm.), encroaching on such areas as the Musquash Marsh, the largest Fundy salt marsh outside the head of the Bay. A proposed terminal structure could result in conversion of a large proportion of this salt marsh. A few miles west of Saint John, at Lorneville, development of a large complex of oil terminals and ancillary industries is under way. A study by Pearce and Smith (1974) emphasized the potential environmental impact of oil spills from this development on wetlands in the area.

3.3 ENERGY-RELATED DEVELOPMENT

Canada's wetlands are also endangered by the ever-growing demand for energy production and transmission: the impoundment of reservoirs for hydro-electric generation has flooded extensive wetland areas; the control of river regimes has altered delta marshes and mudflats; and the construction and maintenance of an extensive network of transmission lines has interfered with a wide range of wetland areas. Furthermore, the recent search for energy alternatives has introduced two new threats to our wetlands resource: the harnessing of tidal power and the extraction of peat for the generation of electrical energy.

Many studies have assessed the environmental impact of energy developments on specific wetlands. Because it is beyond the scope of this paper to give a comprehensive assessment of this documentation, only certain high-profile projects of national significance have been included to provide an overview of tidal and peat power production.

Although the W.C. Bennett Dam on the Peace River has not involved the direct conversion of wetlands, it has resulted in wetland area loss. The Peace-Athabasca Delta of northeastern Alberta (Figure 1) is ranked among the largest freshwater deltas and the most biologically productive wetlands in the world. Covering an area of 4 400 km^2, a major portion of the Delta is situated in Wood Buffalo National Park, and is the foremost delta in the National Park System. The Delta provides high quality waterfowl habitat, which is especially important during drought years on the southern prairies, and because of continued drainage of the prairie potholes; it is a key link in all four North American flyways which cross it. The Delta also plays a major role in the well-being and life-style of the local people and their regional economy.

The construction of the W.C. Bennett Dam in 1968, 1 170 km upstream, effectively reduced spring flooding and average water levels on the Delta. By 1970, more than 50 000 ha of mudflats were exposed, which resulted in the replacement of the original marsh vegetation by grassland and willow scrub. Infrared aerial photography has been used annually since 1975 to carry out surveys of the Delta's vegetation: this has revealed that ice-jam floods have resulted in replenished vegetation occasionally since 1972, although it remains to be seen whether the ecology of the Delta will survive in the long term (Hughes and Cordes, 1981).

The Peace-Athabasca Delta Project Group, an intergovernmental committee formed in 1971 to conduct an investigation into the problem of low water levels on the Delta, projected a long-term 50% decline in shoreline which is important to many wildlife species. The group anticipates a permanent reduction by 0.3 metre in average summer levels, advancing vegetational succession, and the shifting of plant zones to lower elevations around lake margins. The group also expects waterfowl production to decline by approximately 20-30% due to the loss of suitable habitat (The Peace-Athabasca Delta Project Group, 1972b). Damage to the fish and wildlife populations will affect a major source of income for the Chipewyan Indian Reserve, located on the Lake Athabasca portion of the Delta. This issue provides a good example of the complexity of the legal and jurisdictional framework for water management in Canada (The Peace-Athabasca Delta Project Group, 1972b), since Lake Athabasca (which is adjacent to the Delta) traverses both Saskatchewan and Alberta, and the headwaters of the Peace River are in British Columbia.

Recent research has been directed at the establishment of operational monitoring techniques for the Delta. Studies such as Wickware and Howarth (1981) provide remote sensing methodologies for quantifying changes in wetland delta habitat areas. A similar study by Jaques (1983) indicates that a satellite-based remote sensing methodology for monitoring wetland habitats on the Churchhill River is practical.

There are problems on the Saskatchewan River Delta (Figure 1) which are similar in nature to the Peace-Athabasca Delta, albeit on a smaller scale. Changes in the flows of the North and South Saskatchewan River, and hence the water regime of the Delta, are the result of several activities, including the construction of two dams for the generation of hydro-electric power. River flow has also been controlled to some extent by installations for irrigation and recreation. The Saskatchewan River Delta is an extremely productive wildlife habitat, and and provides an integral part of the livelihood of many delta residents. It is clear that the fluctuating water levels of the Delta have adversely affected the fish, fur-bearing animals, and waterfowl on which the local economy depends, even though the extent of this impact has not been accurately defined. A committee formed in 1971 called for further investigation into the nature and magnitude of the ill-effects of manipulated river flows (Committee on Saskatchewan River Delta Problems, 1972).

Similar effects on large wetland habitats are also possible in the James Bay Development Territory in Quebec, the Churchill Falls development in Labrador, the Nelson River in Manitoba, and the Columbia

River in British Columbia.

According to the terms of the Columbia River Treaty, after 1984 Canada will be permitted to divert over 42 000 m^3 of water annually from the Kootenay River to the Columbia River, in the vicinity of Canal Flats in southeastern British Columbia (Figure 1). This diversion would result in a significant net energy gain in British Columbia, and conceivably, an economic boost to the region's development in the short term. Preliminary feasibility studies and potential impact assessments for the plan were completed in 1977 (British Columbia Hydro and Power Authority, 1977).

The diversion would also cause increased flows in the Upper Columbia River. The valley bottom is largely a system of lakes and marshes extending over a distance of 160 km, and the flooding caused by unmitigated diversion would have severe impacts on wildlife and property (British Columbia Hydro and Power Authority, 1977). The Columbia River Marshes are a productive area for waterfowl and are located on a major flyway used by numerous species of ducks, geese and swans. Many other species of fish and wildlife also use the wetland habitat. Modified concepts of the diversion scheme have been proposed to minimize environmental damage, but resource managers in British Columbia are still apprehensive about the development (P. Cowtan, pers. comm.).

The interest in tidal-power development in Canada has been focussed on the Bay of Fundy, where the tides are among the highest in the world. Dams would be required to maintain a hydraulic head in smaller bays and valleys along the Fundy shoreline, the flow from which would be controlled to generate electricity. These dams would have an effect on tidal amplitude and therefore on tidal wetlands, particularly the salt marshes situated at the head of the Bay of Fundy (Pearce and Smith, 1974).

Several sites have been the subject of feasibility studies over the past three decades: Passamoquoddy and Cobscook Bays, located on either side of the border between New Brunswick and Maine; Shepody Bay, Cumberland Bay, and Cobequid Bay in Minas Basin, all located at the head of the Bay of Fundy (Figure 3). These studies conclude that despite the technological practicability of the schemes, prevailing economic conditions render them unfeasible. Pearce and Smith (1974) examined the potential effect of altered tidal regimes on salt marshes and their use by waterfowl. They concluded that waterfowl use of Passamaquoddy Bay and Cobequid Bay would probably only be minimally influenced by the power structures, despite some reduction of wetland area. Because Shepody Bay and Cumberland Bay are bordered by extensive salt marshes and mudflats, enclosure of these bays would have much more substantial influence on wetland area and on waterfowl use. Further studies are required to adequately appraise these changes and to assess potential impact on seabirds and shorebirds.

Construction of a tidal-power generating station has been proposed for the lower reaches of the Annapolis River Basin in southwestern Nova Scotia (Martec Limited, 1980) (Figure 3). To-date, a feasibility project has been completed at Annapolis Royal. Bay of Fundy tides would be

harnessed for power using an existing barrage which was constructed across the lower Annapolis River in the 1960's to protect marshland from tidal inundation. An assessment of the potential impact of this project (Martec Limited, 1980) contains no areal estimates of wetland conversions; there apparently is little concern for further encroachment on the wetland resource, since the area has already been modified by the barrage. The Annapolis River Valley is generally not considered to be an important area for wildlife, primarily because of its lack of undisturbed habitat (Martec Limited, 1980). There is concern, however, that raised water levels will impede the drainage of agricultural dikeland.

The potential of peat as an alternate energy source is receiving considerable attention. Although Canada ranks only second after the USSR in peat reserves, the use of peatlands in Canada for energy has been minimal to-date. Uncertainties about the extent and quality of peat resources, the economic feasibility of generating peat-fired electrical energy, and the long-term environmental impacts associated with peat mining, have thus far hindered the development of large-scale utilization of the resource. In the last decade, however, research has been aimed at answering these questions. Inventories are being undertaken and technical studies are addresssing problems associated with harvesting, processing and transportation. Peat regeneration and harvest site reclamation are being investigated. In general, current research recommends a limited scale of peat exploitation for energy, although the future of the resource is dependent on more detailed economic and technical evaluations (Monenco Ontario Limited, 1981; Wells and Vardy, 1980).

The Maritime provinces may be in a more favourable position to use peat for electrical generation due to their reliance on oil-fired stations (D. Stewart, pers. comm.). In Newfoundland, experts are considering large-scale development of their peatland resources in order to reduce dependence on imported oil (Wells and Vardy, 1980). The island has concentrated peat deposits in the west and southeast, which could possibly supply one-third of its demand for electrical energy (Wells and Vardy, 1980). Current uses of peat in those areas include agricultural and forestry research, as well as some small-scale farming and peat moss operations.

Peat from bogs and fens is being harvested across the country for horticultural application, as well as for energy purposes. According to Monenco Ontario Ltd. (1981), there is a total of 50 582 000 ha of potential or inferred peat land in all the provinces, with Alberta, Ontario, Quebec and Nova Scotia being the most bountiful. The value of peat produced in Canada in 1980 totalled over $42 million (Brady, 1981). A discrepance often exists, however, between potential and actual production: Ontario, for example, may have 34% of the nation's peat resources but currently accounts for less than 2% of the total value of peat produced.

The extraction of peat in New Brunswick, which is concentrated in the northeastern coastal plain, has traditionally been for horticultural use. Gemmell and Keys (1979)

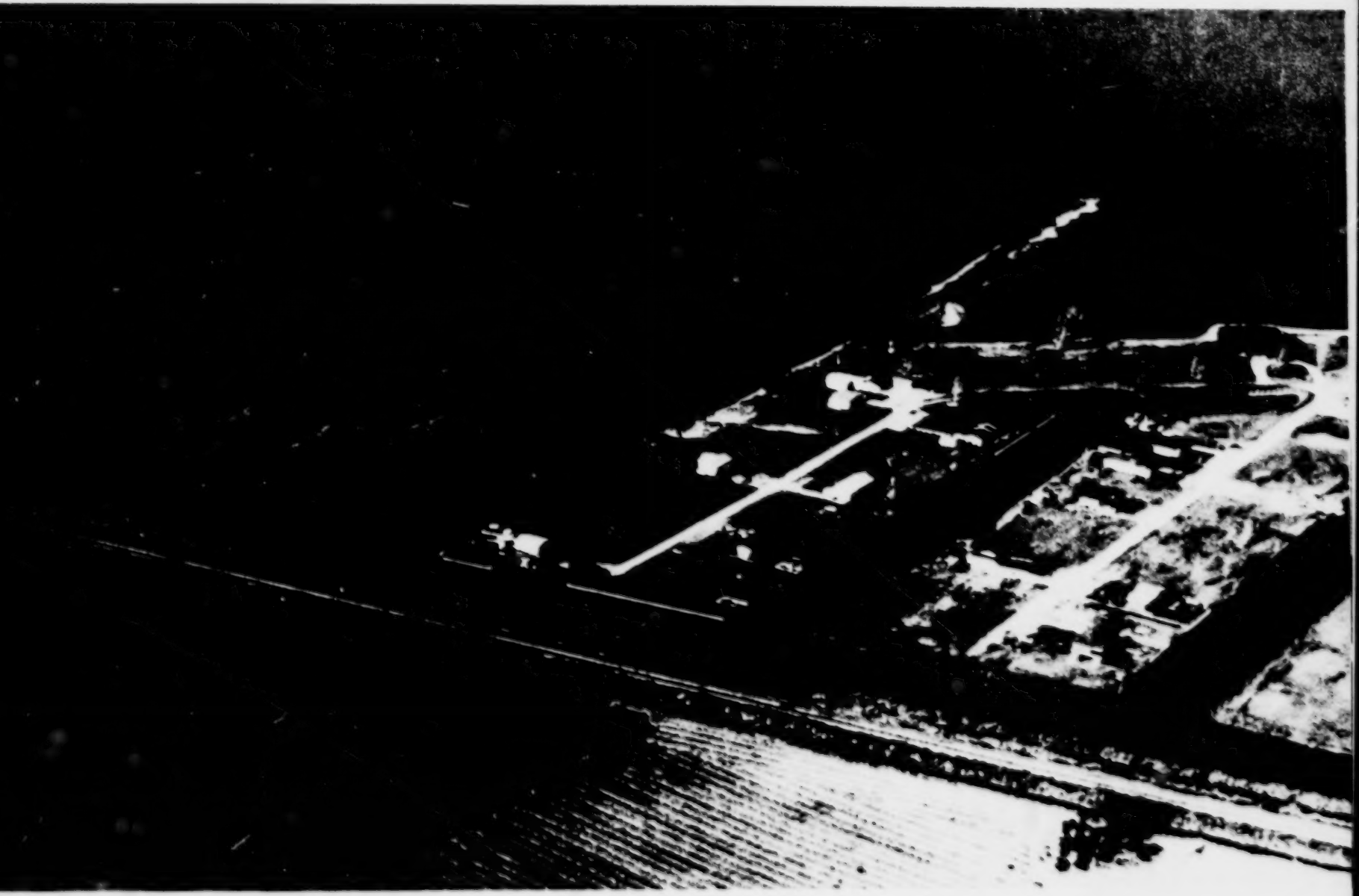

Plate 5: The development of leisure homes and associated recreational facilities represents a subtle and localized yet important form of wetland conversion.

reported that the eastern and central parts of the province also have significant potential for fuel peat production. To this end, a feasibility study of a steam-electric power station for the Shippegan area of northern New Brunswick has recently been completed. The study concludes that such a station is economically feasible when compared to an equivalent size of oil or coal-fired station. Approximately 2 100 ha on 21 peatlands would be required to supply the station (Keys, 1980).

In Ontario, development of peat for energy uses does not represent a solution to the energy problem, although a recent provincial government investigation indicated that it could be a viable option for remote communities in northern Ontario (Monenco Ontario Limited, 1981). Various uses of peat were studied: space heating, district heating, industrial process heat generation, and power generation using a small-scale gasifier. From a preliminary evaluation, these applications appear favourable, but environmental, technological, and economic uncertainties may hinder further development. It is expected that the greatest pressure for peat extraction will be in northern Ontario, due to both the considerable supply and the anticipated demand in that area. Based on climatic factors only, Monenco Ontario Limited (1981) ranked areas of the province according to peat mining and production potential: southern Ontario was the most favourable, followed by the regions of Sudbury (central Ontario) and Rainy Lake-Kenora-Red Lake (northwestern Ontario), which were of comparable suitability.

A recent workshop focussed on the status of peat developments across Canada (Morgan and Pollett, 1983). At the federal level, interest in the use of peat for energy generation is being explored by the National Research Council Peat Forum. Rubec and Moore (1982) give an overview of the land use monitoring of wetlands in relation to Peat Forum activities. They note that monitoring the effects of harvesting on associated land uses should be an integral part of peatland development proposals, and that such monitoring should be undertaken cooperatively by both federal and provincial agencies with the expertise required.

The effects of forest clear cutting on peatland and wetland ecosystems throughout Canada are not well documented. Forest practices which do not lead to re-planting of cleared peatlands are leading to a significant decline in the ecological (especially drainage) conditions and overall quality of peatlands (G.M. Wickware, pers. comm.).

3.4 RECREATIONAL USE

Recreation on and adjacent to wetlands across Canada is at once both a reason for the preservation of wetlands and a factor in their decline. Activities such as game-bird hunting, fishing, bird-watching, hiking, and nature photography are considered "non-destructive", except in cases of overuse or disregard for the fragility of the ecosystem. Organizations which promote these recreational activities are often instrumental in the protection of wetlands through political lobbying, wetland acquisition, or wetland management.

There are, however, "destructive" recreational uses which have largely accompanied the trend toward acquisition of leisure

homes on lakeshore sites. Coupled with the fact that many rural economies have benefitted from tourist spending in vacation periods, wetlands have been widely perceived as nuisance areas or wastelands. Marshes have been fragmented and eliminated in efforts to clean up the shoreline, dredged and deepened to provide bathing areas and boat access, infilled for the extension of cottage lots, and eradicated by the construction of docks and marinas. Ironically, the resulting loss of wetlands degrades the natural assets which originally attracted people to the area. A decline in fish and wildlife populations, impaired water quality, and a noticeable loss of "natural aesthetics" are all possible effects of wetland destruction.

Although wetlands continue to be eliminated from recreational waterfronts across Canada, the most detailed reports available pertain to the situation in Ontario. A study by Lewies and Dyke (1973) treats this issue in the Kawartha Lakes region (Figure 2), a system of about 15 lakes located 150 km northeast of Toronto on the Trent-Severn waterway. The Kawartha Lakes region is an extremely popular recreational area for vacationers from urban centres along Lake Ontario's north shore. It has been reported that 75% of the original marshland along the Kawartha Lakes has been converted, mostly for recreational development (Kawartha Region Conservation Authority, 1981). Lewies and Dyke (1973) measured losses which occurred in the Kawartha Lakes region between about 1960 and 1969, noting that 20% of the pre-1960 marsh area had been eliminated in that period. Laidlaw (1978) indicated that similar wetland area losses have occurred throughout the Trent-Severn and Rideau River systems between the 1930's and 1960's. Recreational development appears to be slowing down in these areas as a result of prevailing economic conditions, the declining availability of accessible cottage lots, and increasingly restrictive regulations with respect to private ownership of lakeshore lots.

Substantial areas of the Lake Erie shoreline have also been converted to privately owned cottage lots (Laidlaw, 1978). Heffernan and Nelson (1979) have expressed specific concern about recreational expansion along Long Point, the largest peninsula on Lake Erie (Figure 2). Composed of a succession of sand bars with marsh and open water between the bars, it stretches 32 km into the lake. The Long Point area contains some 4 000 ha of marsh, which is a major habitat for migrating waterfowl and fish. Recreational activities appear to have dramatically influenced the northwestern portion of the Point (Heffernan and Nelson, 1979), especially since the construction of a causeway from the mainland to the Point. It is predicted that further wetland conversion will accompany the increase in regional population that is expected with the development of a nearby large-scale industrial project. In a study of Big Creek Marsh at the head of Long Point, Hardy (1980) notes that, because of the lack of well-drained areas, recreational development will probably occur in former wetlands on dredged materials. The study concludes that fragmented ownership of large marshes and differing management strategies pose a major threat to wetland integrity, and urges a holistic approach to marsh management.

4.0 SUMMARY AND CONCLUSIONS

1) There are significant gaps in the available information related to land use change on and adjacent to wetlands in southern Canada, making a national overview of wetland conversion difficult to achieve.

   (i) Valuable quantitative reports do exist on general trends in wetland conversion, but an accurate, comprehensive view of the national situation is abscured by information gaps, overlaps and inconsistencies.

   (ii) Existing research fails to adequately represent the many and varied types and functions of wetlands in southern Canada.

   (iii) From a national perspective, significant gaps also exist in the analysis of the social, economic and legislative factors involved in the conversion of wetlands to other uses.

2) Agricultural reclamation has been the major force behind wetland decline in southern Canada. Related activities, particularly drainage, continue to threaten a dwindling wetland area. Regions of specific concern regarding past, present and/or anticipated pressure include:
   i) the prairie pothole region of Alberta, Saskatchewan, and Manitoba,
   ii) southern Ontario, especially southwestern Ontario, the south Georgian Bay area and the eastern counties;
   iii) the Tantramar area, straddling the border of New Brunswick and Nova Scotia;
   iv) the Fraser River Delta, the Cariboo-Chilcotin region of the interior plateau, and the Peace River-Fort St. John area of British Columbia; and
   v) the south shore of the St. Lawrence River estuary in Quebec.

3) The dredging, draining and filling of wetlands for urban and industrial development has been exerting increasing pressure on a severely reduced wetland base over the past few decades. Regions of specific concern regarding past, present and/or anticipated pressure include:

   i) the wetlands of the St. Lawrence River and Lower Great Lakes shoreline, especially the north shore of Lake Ontario; and

   ii) the shorelines and estuaries of the Pacific and Atlantic coasts, especially the Fraser River Delta and other coastal estuaries in British Columbia and, to a lesser extent, estuaries near Halifax and Saint John.

4) Canada's wetlands resource also suffers under the increasing demand for energy production and transmission. Current issues include:
   i) the control of waterways for the development of hydro-electric power projects throughout Canada;

and

ii) the production of energy from tidal and peat resources.

5) Recreational land uses represent a subtle, localized yet important form of wetland conversion, particularly in relation to the development of leisure homes and associated recreational facilities.

6) The awareness and concern expressed by a wide range of resource agencies and their current and proposed research efforts are reason for optimism. However, the number and diversity of those agencies, the widespread significance of the wetlands issue, and the reality of limited funding necessitate cooperation and collaboration among researchers to ensure effective results. Current avenues of cooperative research include the inventory, evaluation, and priority assessment of wetlands; and the increasing application of satellite data for wetlands monitoring.

5.0 RECOMMENDATIONS

(1) It is recommended that monitoring program(s) be initiated to document the rate and extent of land use change on wetlands across Canada. The identification of past and current trends in land use is an essential, initial step in the formulation of natural resource strategies. The conflict between wetland functions and their alienation by agriculture, urban, industrial, energy development, and recreational land uses is of pressing concern and of national significance. The following approaches should be considered:

(a) Definition of conflict areas can be achieved, on a broad scale through the use of secondary sources such as Canada Land Inventory (CLI) data.

(b) Land use change on wetlands of extensive regions exemplifying national wetland types, values and land use pressures, should be analysed using stratified sampling techniques incorporating both air photo analysis and field reconnaissance. Such an approach is currently applied to the prairie pothole region of Western Canada. The widespread, yet detailed scrutiny afforded by this technique is essential to accurate, comprehensive assessment of the complex prairie situation.

(c) A series of site specific, "focussed" wetland monitoring studies comprising a representative range of wetland types and intensity of land use pressures across Canada should be undertaken. The following areas should be considered for such an approach.

Atlantic Region: (i) Saint John Area coastline (from Canaports to Lorneville); (ii) Halifax Area (including Chezzetcook Inlet); (iii) Chignecto Isthmus (including marshlands of Aulac, Missaguash, La Planche, and Tantramar rivers); and (iv) Northeast New Brunswick.

Quebec Region: (i) Montreal Urban Centred Region; and (ii) selected key sites in St. Lawrence Estuary.

Ontario Region: (i) Southwestern Ontario (counties of Kent, Essex and Lambton); (ii) South Georgian Bay Region (counties of Grey, Dufferin, and Simcoe); (iii) Eastern Ontario (non-shield areas east of a line through Frontenac and Renfrew counties); and (iv) Lake Ontario Northshore (Oshawa region in particular).

Western Region: (i) Prairie Pothole Region; (ii) South Saskatchewan River Delta; and (iii) Peace-Athabasca Delta.

Pacific Region: (i) Fraser River Delta (foreshore banks to New Westminster); (ii) one of Cowichan, Chemainus or Nanaimo Estuaries, on Vancouver Island; and (iii) Cariboo-Chilcotin Region.

(2) Within the "focussed study" approach, it is recommended that the following opportunities be pursued:

a) Cooperation and collaboration of the many agencies currently involved in wetlands research, with similar, or mutually supportive objectives. This would encourage a multidisciplinary perspective which would be most effective in this type of research.

b) The integration of land quality and ownership factors in land use change research, both significant factors in wetlands conversion.

c) The assessment of indirect effects of changing land use on wetlands by devoting particular attention to the development of the wetland, and by the detection of vegetation changes.

d) A comprehensive evaluation of the functions and values of wetlands other than for wildlife, and the correlation of wetland area changes with the implications of these changes.

e) The incorporation of results from the noted wetland priority assessment studies (Table 2) in the selection of monitoring areas.

(3) It is recommended that additional research related to the nature of the wetlands conversion issue be pursued. This research should include:

a) The precise definition of interrelationships between wetland system components and the functions they support. This information is essential in determining the quantity and quality of wetlands which must be protected in order to preserve critical functions. Knowledge of the association between waterfowl habitat and wetland ecology appears to be sophisticated at this time, but further details are continually sought.

b) The identification and evaluation of the social, economic and legislative factors which affect land use on wetlands. A limited amount of information on this subject is available, but it is incomplete and fragmentary. Most of the existing sources pertain to agricultural reclamation of wetlands in the prairie provinces and Ontario.

c) The identification and assessment of indirect impacts on wetlands, and the implications of these changes.

(4) It is recommended that a central registry be established, to maintain and expand the existing wetland change data bases. This registry would encourage the growth of the wetlands data base by promoting the improvement and expansion of existing documentation and/or methodologies; by promoting cooperation and collaboration among agencies; and by ensuring the consistency, comparability and comprehensive coverage of research results. It should complement the Wetland Classification Registry established at the Land Resource Research Institute in Ottawa (Tarnocai, 1981).

(5) It is recommended that the organization of a national workshop should be undertaken under the sponsorship of the federal government to focus national attention on wetland land use conversion issues.

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APPENDIX 1

QUANTITATIVE REPORTS ON WETLAND CONVERSION

PROJECT TITLE: INVENTORY AND WETLAND RECONNAISSANCE IN THE PROVINCE OF ALBERTA

REFERENCES

Ritter, A. 1979. "Wetland Reconnaissance within the Battle River Basin: 1978 Summary." Unpublished report prepared for Ducks Unlimited Canada. 36 p.

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OBJECTIVE

To systematically identify, investigate and rate existing and potential waterfowl production areas toward the generation of new Ducks Unlimited Canada projects. Although the study is primarily an inventory and analysis of waterfowl production potential, the extent and threat of habitat destruction via drainage (to the time of the reconnaissance) is among the major parameters investigated.

STUDY AREA LOCATION

Selected subbasins within the watersheds of the Peace, Athabasca, North Saskatchewan, Battle, Red Deer, Bow, South Saskatchewan, Oldman and Milk Rivers, and Sounding Creek have been investigated. Summary reports were completed for reconnaissances within portions of the South Saskatchewan River Basin (located in the southeastern corner of Alberta) and the Battle River Basin (located in the east-central portion of Alberta).

Areas within provincial parks, and military and Indian reserves were not studied.

METHODOLOGY

Data Sources

(1) National Topographic Service maps (late 1960's) at a scale of 1:50,000
(2) black-and-white aerial photographs (most recent available) generally at a scale of 1:31,680

Data-Handling Techniques

- Areas for field reconnaissance were selected, consisting of one wetland (10 ha and greater) or several individual wetlands (a complex totalling at least 10 ha).
- Parameters investigated included soils of the wetland and upland, vertical and horizontal contour, land use, water

(3) Alberta soil survey maps
(4) landowner contact
(5) field reconnaissance

.permanence and quality, invertebrates and aquatic vegetation, nest cover, and loafing sites.
.Relative rating of wetland waterfowl production capabilities (present and potential) was assessed by subtracting values assigned to factors which limit waterfowl production, from an initial assigned wetland value of 100, thereby reducing the value or rating of the wetlands to some number between zero and 100.
.A level of priority was assessed based on the type of potential production and management, landowner opinion and drainage threat.

OUTPUTS

Reports: (as referenced)

RESULTS AND CONCLUSIONS

(Note: Habitat destruction results drawn from Ritter, 1979, and Schmitt, 1980).

Battle River Basin (to 1978)

Ditched wetlands were recorded for 78 or 37.5% of the total reconnaissances. A total of 37 or 17.8% of the reconnaissances were recorded as drained. The habitat loss to date (1978) attributed to these drained wetlands was estimated at 2 693 ha or 8.9% and 258 shoreline kilometres or 18.0% of the total investigated.

There appears to be a relationship between low mean potential ratings for waterfowl production and high percentages of ditched and drained wetlands for individual subbasins.

The drainage data indicates that considerable waterfowl habitat has been, and is being lost. Many of those wetlands that have been only partially ditched are highly susceptible to further ditching and complete drainage. An effort should be made to secure the remaining wetlands as soon as possible.

South Saskatchewan River Basin (to 1979)

In total, 15 reconnaissances or 16.0%, 938 ha or 21.3%, and 65 shoreline km or 15.0% of all reconnaissances can be termed as "lost" habitat to date.

Drainage via ditching, dewatering via irrigation and "piracy" of the water source via upstream diversions comprised the three major types of habitat destruction.

Productivity was severely reduced in an additional 7.0% of reconnaissances, resulting in 519 more ha of wetland loss.

Wetland habitat loss appears to be related more to water and moisture availability than land value and flooding, as was found in past studies. If habitat destruction of this type continues to be identified in further reconnaissance, a concerted effort should be made to minimize the effects.

Due to the inherent shortage of water in the South Saskatchewan River Basin, extensive efforts to contain spring runoff have been made. A total of 29 or 30.3% of total reconnaissance involved unnaturally created wetlands, representing 1 240 ha or 27.8% of wetland habitat area that has been created. Therefore, a net gain of 301.6 ha and 54.1 km of shoreline is realized. Drainage of wetlands is a serious problem in the study area, and in other areas as well. Much of the drainage that has occurred represents irrevocable loss of wildlife habitat.

PROJECT TITLE: A DOCUMENTATION AND ANALYSIS OF WETLAND DRAINAGE IN THE ALBERTA PARKLAND.

REFERENCE

Schick, C.D. 1972. "A Documentation and Analysis of Wetland Drainage in the Alberta Parkland." Unpublished report of the Western and Northern Region, Canadian Wildlife Service. 15 p.

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OBJECTIVE

To identify wetland changes in an area of the Alberta Aspen Parkland (1900-1970).

STUDY AREA LOCATION

An area within the Alberta parkland, measuring 109 ha, located about 3 km southeast of Edmonton.

METHODOLOGY

Data Sources

(1) township survey plans (1883-1903) at a scale of approximately 1:30,000
(2) government drainage district map (1924) at a scale of 1:63,360
(3) aerial photographs (1950-1962) at scales of approximately 1:30,000 to 1:35,000

Data-Handling Techniques

- Wetlands assumed to be present during pristine conditions were plotted on base maps at a scale of 1:50,000.
- Documented drainage over the 70-year study period was interpreted from a series of plans, maps and stereo air photos and recorded on base maps at a scale of 1:50,000.
- Wetland conditions existing during 1970 were plotted on base maps at a scale of 1:50,000.
- Wetland conditions existing during 1970 were plotted from field data onto base maps at a scale of 1:50,000.
- All measurements of wetland areas were made with either a planimeter or a square grid; however, wetlands under .8 ha in size were not included in this study due to small-scale air photos used.
- Total areas of pristine wetlands were determined from air photos and survey plans.
- Total areas of wetlands affected by drainage were determined from the base maps.
- Total areas of 1970 wetlands were measured from national topographic series maps.

OUTPUTS

(1) Report: (as referenced) includes small-scale maps showing:
i) pristine wetland conditions
ii) wetlands affected by drainage (1900-1970)
iii) wetlands remaining (1970)

(2) Maps: original base maps at a scale of 1:50,000 as noted immediately above.

RESULTS AND CONCLUSIONS

Wetlands assumed to be present during pristine conditions totalled 6 690 ha. During 70 years of settlement (1900-1970), 2 287 ha (34%) were lost through documented drainage for agriculture and 2 582 ha (39%) of wetlands remain in the study area. Therefore, 1 822 ha (27%) have been lost and unaccounted for by the study for a total wetland loss of 61% of the original area.

Most documented drainage occurred between 1900 and 1924. Eighty-one percent of the total losses had occurred by 1950.

Non-documented losses could possibly have resulted from road and railroad construction, natural and man-influenced filling of smaller basins, increased evapotranspiration, unrecorded drainage and the general lowering of the area's water table.

PROJECT TITLE: SPATIAL CHANGES IN WATERFOWL HABITAT ON THE MANITOBA NEWDALE PLAIN

REFERENCE

Adams, G.D., and G.C. Gentle. 1978. Spatial Changes in Waterfowl Habitat, 1964-1974, on Two Land Types in the Manitoba Newdale Plain. Canadian Wildlife Service Occasional Paper Number 38. 29 p.

AGENCY/CONTACT

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OBJECTIVE

To evaluate and compare land-use interactions in relation to spatial changes in wetlands and upland vegetative cover, on two land types described as classes 1 and 3 for waterfowl production capability (1964-1974).

STUDY AREA LOCATION

Two study area blocks, located on the Newdale Plain of the Minnedosa District, southwestern Manitoba. One study area block of 124 sq km was located in each of two land capability classes for waterfowl. Block I, on class 1 land, was subdivided into three portions: (1) 36 sq km north of Basswood, (2) 31 km^2 south of Minnedosa, and (3) 57 km^2 northwest of Rapid City. Block II, on class 3 land, was located near the towns of Hamiota and Oak River.

METHODOLOGY

Data Sources

(1) National Air Photo Library black-and-white aerial photographs (September 1964, August 1965) at a scale of 1:15,000 (A-18611, A-13971,A-13624,A-18609)

(2) C.W.S. Saskatoon infrared aerial photographs (July 1974) at a scale of 1:20,000 (70 mm)

Data-Handling Techniques

- 20 sample plots, of 65 ha each, were randomly allocated within each of the 2 blocks.
- Cover classes were identified through interpretation of stereomatched contact prints and transferred onto traced (1974) or photomap (1964) bases at scales of approximately 1:6,000.
- Seven broad cover and surface water classes were defined for interpretative purposes: cultivated land, grassland, woodland, closed wetlands, open-water marshes, habitations or farmsteads, excavations or denuded land.
- Temporal change and land-use relationships were analysed by delineating, coding and digitizing cover class units using a programmed calculator and digitizer.
- Interactions of the four land-use classes were tested using multiple regression analysis.
- Statistical significance was calculated for results.

OUTPUTS

Report: (as referenced)

RESULTS AND CONCLUSIONS

Although wetland numbers did not change appreciably over the decade, total wetland area increased significantly, from 259.52 ha to 311.46 ha in Block I, and from 95.98 ha to 126.10 ha in Block II. Perimeter lengths generally increased by 7% in Block I and 2% in Block II. There was also a 13% decrease in wooded perimeter length on Block I due to clearing of wetlands present in 1964: 17% were altered by clearing or partial drainage and 7% were eradicated.

The numbers of wetlands destroyed in the study period have been temporarily offset by a gain of wetlands, although those gains are primarily transitory wetlands with open perimeters.

Large-scale drainage was not a significant factor in reducing wetland numbers or permanency in the study (10% of the ponds were drained on both blocks). However, total alterations and losses of wetlands on Block I, including drainage and clearing, affected 27% of the wetlands present in 1964.

Although dissimilar precipitation patterns influencing the observation years tend to mask real habitat changes, a definite trend toward increasing cultivation and reduction of natural cover appeared in the study. Wetland losses, the destruction of grasslands, and the alteration of wetland margins have probably reduced the quantity and quality of available waterfowl nesting habitat.

PROJECT TITLE: THE METHODS AND RATES OF ALTERATION OF WATERFOWL HABITAT IN THE BLACK SOIL ZONE OF WESTERN CANADA

REFERENCE

Goodman, A.S., and S.P. Pryor 1972. "A Preliminary Study of the Methods and Rates of Alteration of Waterfowl Habitat in the Black Soil Zone of Western Canada." Unpublished report prepared for the Canadian Wildlife Service. 77p.

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OBJECTIVE

To obtain preliminary estimates of how much waterfowl habitat remains in existence in its natural state; how much has been created or improved; how much has been adversely affected by man; and what has been the net effect of man's activity on wetlands in the black-soil zone (to 1970).

To relate those changes to various factors and combinations of factors to provide insight about rates, possible causes, type of habitat left, improved or lost, and what physical land classification systems may provide the best stratification for any required additional review.

To determine if present sampling was sufficient for the observed results to be reasonable estimates of the true situation.

STUDY AREA LOCATION

Black soil zone portion of each of the provinces of Alberta, Saskatchewan and Manitoba.

METHODOLOGY

Data Sources

(1) aerial photographs (1945-1969), primarily at a scale of 1:15,840 but ranging from 1:12,000 to 1:63,360
(2) CWS aerial photographs (spring of 1970)
(3) Canada Land Inventory Waterfowl Capability maps (1970's) at a scale of 1:250,000
(4) Canada Land Inventory Agricultural Capability maps at a scale of 1:250,000
(5) soil survey maps and municipal assessment sheets
(6) field reconnaissance

Data-Handling Techniques

- A total sample of 600 quarters was randomly selected.
- Preliminary assessment was made from large-scale air photos.
- Further stereo air photo interpretation of current prints was completed for each quarter on which more drainage could have occurred.
- Detailed data records were generated for each quarter, including land description, waterfowl capability, agricultural capability, topography and soil texture.
- Individual pond records were developed, including pond type, adjacent land use, basin land use, net alteration, date and agents of change, and position of pond in the watershed.
- Various statistical analysis techniques were applied toward the achievement of objectives as listed.

OUTPUTS

Report: (as referenced)

RESULTS AND CONCLUSIONS

Of the original estimated 2 122 pristine ha and 3,737 pristine ponds, this study found that 77.2% or the area and 89.4% of the ponds were still in their pristine condition. Therefore, 411 of 19.3% of the pristine hectares and 337 or 9.0% of the ponds had been "adversely" affected by man's activity. Adverse impacts included, in order of importance, partial drainage, total drainage and partial infilling due to roads.

However, pond impairment and losses have been slightly offset by the improvement and creation of ponds by dugouts, extra inflow and the construction of dams. As a result, an estimated net loss of 272 ha or 12.9% and 168 or 4.5% of the ponds has been experienced in the study area over approximately a 30-year period (1940-1970). This suggests that rate of loss per year is small. Therefore, there is time to alter present landuse practices to prevent destruction of good-quality habitat through long-term careful planning. It would seem reasonable that such planning would involve close co-ordination of the activities of wildlife agencies and agriculture.

It is suggested that planning strategies could use base maps such as CLI agricultural capability maps as a measure of threat, and CLI waterfowl capability maps as an indicator of important habitat.

COMMENTS

This study methodology has also been applied to the brown and light brown soil zones, with an increased sampling frequency. The collected data is currently in raw form and no immediate plans exist for the analysis and report-writing stages.

PROJECT TITLE: PRAIRIE WATERFOWL HABITAT EVALUATION PROGRAM

REFERENCES

Millar, J.B. 1980. Prairie Waterfowl Habitat Evaluation Program. Canadian Wildlife Service Project Report. 158 p.

_____. 1981. Habitat Changes in Saskatchewan Waterfowl Strata 30 to 33 Between Fall 1978 and Fall 1980 - Prairie Waterfowl Habitat Evaluation Program. Canadian Wildlife Service Project Report. 60 p.

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OBJECTIVES

To determine present waterfowl habitat and overall land-use conditions on randomly selected quarter-sections of land located along CWS/USFWS air/ground transect sites in the three prairie provinces.

To assess annually the impact of human activities and natural environmental changes on the baseline waterfowl habitat and land-use conditions.

To determine the changes which have occurred in waterfowl habitat and land use over the past thirty years on the sites studied.

(Note: Due to staff and time constraints, sample sites on only four strata located in southern Saskatchewan were studied in 1979 and comprise the basis of this bibliographic entry. Baseline habitat data and some preliminary historical habitat evaluations were compiled and are also considered briefly. Lack of new photography originally expected from the USFWS handicapped several phases of the program.)

STUDY AREA LOCATION

Southern Saskatchewan, within Canadian Wildlife Service Waterfowl Strata 30-33.

METHODOLOGY

Data Sources

(1) 4X enlargements of LIFT (Lower Inventory for Tomorrow) black-and-white aerial photographs (1970) at scales of 1:17,800 to 1:19,200
(2) field reconnaissance April 25 to June 20, 1979, October 2 to November 6, 1979, April 29 to May 22, 1980 and September 25 to November 4, 1980

Data-Handling Techniques

- 21 sample transect sites were chosen based on aerial survey flight lines, access roads, habitat types and productive waterfowl areas.
- 6 sample quarter-sections were selected along each transect by a semi-random selection process.
- Stereo air photos were analyzed and interpreted as to presence of wetlands and other habitat types and land uses.
- Enlarged outline maps of each quarter were drawn using a mapograph, at a scale of 1:7,680.
- Baseline data was initally interpreted

from air photos and/or field survey including information regarding wetland classification, wetland area, dominant submergent vegetation water-level stage, landuse type and extent on wetland margin, alterations or impacts to wetland area, basin spill level, position of wetland in watershed.
- Areas, and length of perimeters, of landuse or wetland units were measured using the electronic digitizing unit of the Hewlett-Packard 9820 computer.
- Change data for the two-year period (fall, 1978 to spring, 1980) was assessed from field surveys, and qualitative changes in the following wetland habitat factors were recorded: number of wetlands containing water in the spring and fall, dominant vegetation, wetland type, marginal woody vegetation, land use impacts, upland land use.
- Basic statistical analysis was applied to collected data.

OUTPUTS

Report: (as referenced)

RESULTS AND CONCLUSIONS

To October, 1979

A very high percentage (84.2) of all wetlands was found to be strongly affected in some way by human activities as of October, 1979. Transitory impacts, primarily cultivation, occur most frequently on more temporary wetlands, while permanent impacts are associated with the more permanent wetlands.

Total cultivation was the most common transitory impact on Type 0 and 1 wetlands* (total and partial cultivation affected 77.9% of all Type 0 and 1 wetlands). Haying and grazing were the major transitory impacts associated with Types 2 and 3+ wetlands.

The most common permanent impacts on wetlands in the study area were partial drainage, rockpiles, and dugouts or ditches for Types 0 and 1, 2, and 3+ wetlands respectively. Altered watersheds, roads and other fill were permanent impacts of secondary importance on all wetland types.

Lacustrine areas have the least potential for future habitat degradation because such degradation has already progressed to the point where there is little left to be degraded. Ground moraine has already been heavily degraded as far as waterfowl habitat is concerned, but remaining habitats have considerable value and are in the greatest danger of future degradation. Knob and kettle moraine has the most significant potential in terms of the amount of habitat still available and its relative value to waterfowl, but dangers of future degradation are considered less immediate or potentially drastic as those for ground moraine.

1978-1980

Over this two-year period, the number of wetlands affected by one or more transitory impacts increased from 2 058 or 64.1% to 2 346 or 73.0% for the study as a whole. Numbers of wetlands affected by one or more permanent impacts increased from 778 or 24.1% to 881 or 27.3%.

Human impacts on wetlands continued to increase and were most severe on ground moraine in parkland. Cultivation continues to be the most common transitory impact and increases in drainage the most frequent permanent impact. Based on studies to date, an estimated 5% of the individual wetlands can be expected to be affected by new impacts each year.

The surveys also reveal a deterioration in wetland habitat as a result of drought. The percentage of wetlands containing water dropped by over half in 1980.

COMMENTS

*Explanation of wetland "types":

Types 0.1 to 1.2 (excluding Type 0.3): low prairie and wet meadow wetlands

Type 0.3: unclassified, mostly cultivated, wetlands

Type 2: shallow marsh wetlands

Type 3: deep marsh

Type 4, 5.1 and 5.2: transitional open-water, open deep marsh and shallow open-water wetlands

Type 5.3 and 5.4: artificial open-water wetlands (dugouts)

Extensive baseline data was collected and analyzed and is presented in the referenced report. This bibliographic entry considers only a small portion of the "impact" information.

Dr. Millar has collected data of a similar nature on individual wetlands in the Melfort and Swift Current areas (to provide information for the development of the wetland classification) and the St. Denis National Wildlife Area. Formal evaluations and reports of the data per se have not been undertaken. The nature of the data is such that results cannot be translated into values per square mile other units of area.

Wetland habitat data has also been collected by CWS staff in the other prairie provices during their annual spring surveys of the air/ground transects. However, the wetland change data remains in a raw form, a portion of it on computer files.

PROJECT TITLE: PRESENT STATUS OF WATERFOWL HABITAT IN THE PRIME DUCK PRODUCTION AREA OF MANITOBA

REFERENCES

Rakowski, P., R.W. Nero, and R.C. Hutchison. 1974. "Present Status of Waterfowl Habitat in the Prime Duck Production Area of Manitoba." Unpublished report prepared for the Canadian Wildlife Service. 12p.

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OBJECTIVE

To determine the distribution and quantity of waterfowl habitat under direct government control in southwestern Manitoba.

To update information on the trends in land use affecting duck production habitat in the Minnedosa pothole region (to 1974), using transect areas devised by Kiel et al (1972).

STUDY AREA LOCATION

Southwestern Manitoba, identified as being that area contained within four National Topographic Service map sheets: Virdon (62 F), Brandon (62 G), Neepawa (62 J) (excluding Interlake area), and Riding Mountain (62 K).

The Minnedosa pothole region (within southwestern Manitoba) as described in Kiel et al (1972).

METHODOLOGY

Data Sources

(1) Canada Land Inventory Waterfowl Capability maps at a scale of 1:250,000
(2) Manitoba Crown Lands Book (1974) showing distribution of crown lands
(3) L.I.F.T. (Lower Inventory for Tomorrow) aerial photographs (1970) at a scale of 1:85,000
(4) field reconnaissance
(5) Minnedosa waterfowl habitat study by Kiel et al (1972)

Data-Handling Techniques

- Areas of capability class 1 to 5, and provincially and federally controlled lands were measured for each map sheet using a random-dot grid.
- Total amount of classes 1 to 5 waterfowl habitat was determined for each map sheet.
- Amount of crown ownership in each class was determined.
- Crown ownership area as a percentage of class total was calculated.
- Land-use types were interpreted on stereo air photos and classified as cultivated and cleared land, woodlots and bushland, and wetland.
- Land-use information was transferred from air photos to base maps at a scale of 1:50,000.

- Field checks of original transects (Kiel et al, 1972) were carried out to further update and verify data.
- Measurements of land-use type areas were determined by random-dot grid.
- Changes were calculated based on previous study.

OUTPUTS

(1) Report: (as referenced)

(2) Maps: original base maps at a scale of 1:50,000.

RESULTS AND CONCLUSIONS

Waterfowl production is dependent on privately owned lands in southwestern Manitoba. Crown-owned waterfowl habitat area is primarily of a low-quality nature. Changes in land use, especially intensive and increased cultivation, clearing and pothole filling, have a critical bearing on waterfowl production in Manitoba.

The waterfowl production capability of former years has diminished, with a 57% decline in total wetland area in the period 1929-1974, and this downward trend in continuing. Transects were rerun in 1982 and information is now available.

PROJECT TITLE: WATERFOWL BREEDING GROUND POPULATION AND HABITAT SURVEYS

REFERENCE

Kiel, W.H., Jr., A.S. Hawkins, and N.G. Perret. 1972. Waterfowl Habitat Trends in the Aspen Parkland of Manitoba. Canadian Wildlife Service Report Series 18. 61 p.

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OBJECTIVES

To describe duck habitat: its genesis, variability and relative importance to the species of waterfowl using it (1928-1930 to 1968).

To determine the impact of road building, land clearing and drainage on waterfowl habitat trends in the Minnedosa pothole region, 1946-1964.

STUDY AREA LOCATION

A representative sample of the aspen parklands, the 10 600 km^2 Minnedosa pothole region in southwestern Manitoba, often referred to as the Newdale-Erickson district. It lies largely south of Riding Mountain National Park, bounded roughly on the south and west by the Assiniboine River, and on the east by the escarpment between the first and second prairie steppes.

METHODOLOGY

Data Sources

(1) National Air Photo Library black-and-white aerial photographs (1928-1930, 1946, 1948 1958, 1962, and 1964) at a scale of 1:15,840
(2) field reconnaissance
(3) hydrological records

Data-Handling Techniques

- 12 ¼-mile-wide ground transects were selected, each having 100 well-defined basins which at that time contained water and were visible from a road.
- 120 potholes (10 along each transect) were randomly selected for more intensive study in breeding and production surveys.
- Land uses were interpreted from a sequence of stereo air photos (1928-1964) and classified as cultivated and cleared land, woodlots and bushland, and wetland.
- Measurements of the areas of the land-use types were determined for each series of photos in the sequence using a dot planimeter, to establish the trends in land-use change or "alterations" over time.
- Interpretation was verified by field checking from 1949.
- Vegetation and permanence of potholes were classified by field checking from 1949.
- Man-made alterations were related to pothole and vegetation types.
- Precipitation over the time period was also considered in the analysis.

OUTPUTS

Report: (as referenced)

RESULTS AND CONCLUSIONS

Man is affecting potholes at an increasing rate. One-half of the sample of 120 potholes were affected by man-made alterations one or more times during the period, 1949-1964. Over 50% of the changes were made during the last four years of the period.

Activities affecting potholes include: clearing of edge and nearby upland vegetation and cultivating the basin (37%); drainage and filling for road building (13%)*, and drainage, both partial and complete (16%). The study area experienced a 27% decline in total wetland area in the period 1928-1930 to 1964.

Bush clearing, pothole drainage and land leveling may not be the best way to satisfy the demands of a growing world food market. The future of the parkland and prairie potholes and their wildlife rests ultimately with the landowner.

*Note: Because observations were on roadside transects, this rate is not typical of the Minnedosa district as a whole. Rates of pothole drainage may be higher near improved roads, via convenient roadside ditches. However, a large proportion of potholes are susceptible to such impact since roads surround almost every section of land. Land clearing is largely independent of roads.

COMMENTS

An extensive section providing the historical background for the study area serves as an introduction to the report.

Discussions on natural changes in habitat (primarily water levels and vegetative cover in relation to precipitation) and waterfowl population trends are also included in the report.

PROJECT TITLE: A PRELIMINARY REPORT ON THE STATUS OF THE KAWARTHA LAKES MARSHLAND

REFERENCE

Lewies, R.W., and R.D. Dyke, 1973. "Wetland Gains and Losses." Unpublished report prepared for the Lindsay District, Ontario Ministry of Natural Resources. 8 p.

McCullough, G.B., and J. Collins. 1976. "Wetland Destruction: The Rideau-Trent-Severn Waterway. A Problem Statement." Can. Wildlife Serv. and Environment Canada. Unpublished Report. 9 p and Appendix.

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OBJECTIVE

To prioritize the Kawartha Lakes, based on marsh per unit area of lake and rate of marsh loss (1960-1969) for the purpose of guiding management activities.

STUDY AREA LOCATION

The Kawartha Lakes area, including Balsam, Bald, Buckhorn, Cameron, Canal, Chemung and Mud, Clear and Stony, Katchiwano, Lower Buckhorn, Lovesick, Mitchell, Pigeon, Rice, Scugog and Sturgeon Lakes.

METHODOLOGY

Data Sources

(1) Ministry of Natural Resources aerial photography (1953-1971) at a scale of 1:15,840
(2) F.R. 3 lake survey reports
(3) field reconnaissance

Data-Handling Techniques

- Lake marsh status was analyzed using two sets of stereo air photos for an interval greater than 9 years within the range 1953-1971, depending on availibility of photographs.
- Marsh areas were delineated on maps traced onto plastic overlay from air photos.
- Marsh area measurements were determined using a polar planimeter.
- Lake acreages were extracted from survey reports.
- Marsh per unit lake area was calculated.
- Photo interpretation was verified by field checking.

OUTPUTS

(1) Report: (as referenced) includes summary tables of vegetation zone area measurements for each marsh, appended to the report.
(2) Maps: original base maps.

RESULTS AND CONCLUSIONS

Total marsh area on fourteen lakes in the Kawartha region decreased by 915 ha for the approximate period 1960-1969, representing a loss of about 20% of the original marsh area. Changes in marsh area on individual lakes ranged from an increase of 8 ha, representing a 21% gain of marsh area, to a decrease of 343 ha, representing a 75% loss of marsh area.

Marshland on the Kawarthas, in spite of its critical importance to wildlife, is endangered and in need of protection. Conservation measures, from acquisition to legislation, must be considered and action taken to minimize further loss, with specific attention to the priority lakes as defined.

COMMENTS

The study refers only to "development" as the reason for the decrease in marsh area. As the study area represents a major focus for cottage development in Ontario, it is assumed that the construction of leisure homes and related facilities was the primary factor associated with marsh loss in the Kawartha Lakes region.

PROJECT TITLE: WETLAND LOSSES IN LAKE ST. CLAIR AND LAKE ONTARIO

REFERENCES

McCullough, G.B. 1981. "Wetland Losses in Lake St. Clair and Lake Ontario". Proceedings of the Ontario Wetlands Conference. Ed. Anne Champagne. 18-19 September 1981, Toronto, Ontario. pp. 81-89.

AGENCY/CONTACT

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OBJECTIVE

To examine wetland losses in Lakes Ontario and St. Clair to provide examples of the pressures that shoreline wetlands have been and are experiencing.

STUDY AREA LOCATION

Privately owned wetlands on the eastern shoreline of Lake St. Clair from the mouth of the Thames River north to Chenal Ecarte.

The Lake Ontario shoreline from the Niagara River to and including Prince Edward County.

METHODOLOGY

Data Sources

(1) National Topographic System maps (1965) at a scale of 1:25,000
(2) Ontario Ministry of Natural Resources black-and-white aerial photographs (1972 and 1978)
(3) aerial reconnaissance

Data-Handling Techniques

- Base conditions were determined from topographic maps.
- Current conditions were determined from air photos and verified by aerial reconnaissance.
- Areas were measured using a polar planimeter.

OUTPUTS

Report: (as referenced)

RESULTS AND CONCLUSIONS

Lake St. Clair

Study of the 32-km section of shoreline from the Thames River to Walpole Island revealed that a total of 882 ha of privately owned wetlands were converted to alternate uses between 1965 and 1978, representing 25% of the area present in 1965. Drainage for agriculture accounted for 91% of the wetland loss, while recreational marina/cottage development accounted for the other 9%.

On the Walpole Island Indian Reservation, 508 ha of wetland were drained for agricultural purposes from 1963 to 1978. This represents a 4.5% loss from the 11 368 ha present in 1963. In addition, many hectares of wetland were enclosed by dikes.

Lake Ontario

For the shoreline of Lake Ontario west of the Bay of Quinte, an estimated 42% of the wetland

area has been lost (early 19th century to late 1970's). Wetland losses have been severe in the heavily populated west end of Lake Ontario from the Niagara River to and including Oshawa. Approximately 83% of the original marshland has been destroyed or degraded. Wetlands have generally faced urban development pressures, possibly the greatest being commercial and recreational harbour development. Adjacent industrial, residential and recreational developments have contributed to the problem.

Eleven percent of the original marshland has been destroyed along the shoreline from Oshawa to and including Prince Edward County.

PROJECT TITLE: ASSESSMENT OF THE EFFECTS OF URBANIZATION AS A BASIS FOR THE MANAGEMENT OF THE WATERFRONT MARSHES BETWEEN TORONTO AND OSHAWA, ONTARIO

REFERENCE

Lemay, M.H. 1980. "Assessment of the Effects of Urbanization as a Basis for the Management of the Waterfront Marshes between Toronto and Oshawa, Ontario." Unpublished M.A. Thesis for Regional Planning and Resource Development, University of Waterloo. Waterloo, Ontario. 280 p.

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OBJECTIVES

To document the changes in freshwater marshes along the shore of Lake Ontario between Toronto and Oshawa, Ontario (1931-1976).

To compare the effects of various land-use changes on different types of marshes and to deduce guidelines for the management of wetlands in urban areas.

STUDY AREA LOCATION

Eight freshwater marshes located along 39 km of the Lake Ontario shoreline between Toronto and Oshawa, including: Lower Rouge Marsh, Frenchman Bay Marsh (northern section), Duffin Creek Marsh, Shoal Point Marsh, Cranberry Marsh, Lynde Creek Marsh, Camp X Marsh, and Second Marsh.

METHODOLOGY

Data Sources

(1) geological reports, soil survey reports and historical topographical maps
(2) National Air Photo Library aerial photographs (1927-1976) at scales ranging from 1:12,000 to 1:50,000
(3) stream flow and lake level records
(4) recreational surveys and planning reports
(5) interviews with public officials and local residents
(6) field reconnaissance

Data-Handling Techniques

- The morphological description of marshes was compiled from existing sources.
- Changes in physical and land-use features in and near each marsh were interpreted from a sequence of air photos covering a period of 45 years (1931, 1946, 1960 and 1976) and verified from existing sources.
- Evidence of direct encroachments, methods of reclamation or disturbance, land-use purpose of encroachment, land-use change in the watersheds, man-made alterations to the related drainage networks, and structural changes to the shoreline, was documented.
- Estimates of reclaimed marsh were obtained by measuring surface areas using a polar planimeter, from maps redrawn from air photos.
- Documented historical changes in the water regime for each marsh were considered in the analysis.
- Vegetation was analyzed by air-photo interpretation and linear transect survey.

- Water quality was tested by several physico-chemical analyses.
- Information regarding recreational use and potential of the marshes, ownership, plus imminent development proposals and their status was compiled and reported.

OUTPUT

Report: (as referenced)

RESULTS AND CONCLUSIONS

The amount of marsh shoreline in 1976 represented a 50% decrease since 1931. The marsh area in 1976 (210 ha) represented only 56% of the marshes existing in 1931 (374 ha), and only 44% of the marshes thought to exist circa 1860.

Agricultural activities were responsible for most of the losses in marshland up until 1930. Drainage in particular accounted for 50% of all reclaimed land. Agricultural activities accounted for only 3.6% of reclaimed marsh after 1931. In the last four decades, marshes were preempted by the following activities, in order of importance: industrial activities (harbours, manufacturing plants), urban utilities (water pollution control plants, line construction), and residential activities.

Changes in water balance, water chemistry and substrate conditions caused by construction are perhaps as important as the net losses in marshland, at least in an urban context.

Effective management of wetlands and natural areas in an urban setting requires a greater commitment at the municipal level. Explicit policies should be formulated, reflecting specific management objectives, and sensitive to the degree of change undergone in a marsh, to public appreciation and to the need to restore site conditions. Selection and implementation of a management program should be based on a sound understanding of the regional wetland resource.

PROJECT TITLE: ESTIMATES OF CLEARED WETLANDS IN SOUTHERN ONTARIO

REFERENCE

Cox, E.T. 1972. "Estimates of Cleared Wetlands in Southern Ontario." Unpublished report prepared for the Wildlife Branch, Ontario Ministry of Natural Resources. 3 p.

AGENCY/CONTACT

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OBJECTIVE

To estimate total area of wetland soils and cleared wetlands (to 1950) in southern Ontario.

STUDY AREA LOCATION

Southern Ontario, except for Parry Sound, Nipissing and Muskoka Districts, and the Counties of Haliburton and northern Peterborough.

METHODOLOGY

Data Sources

(1) Ontario Soil Survey published and unpublished reports (mapping done 1946-1968)
(2) Ontario Forest Resource Inventories (1960) (photographs from which data was compiled were taken in 1950-1953)

Date-Handling Techniques

- Totals of poor drainage, very poor drainage and bottom lands, and organic soils and marsh were calculated from soil reports and considered to represent total wetlands.
- Wetland losses were estimated in two ways:
  i) General land use descriptions such as "all", "most", "much" and "some" were extracted from the text of the reports and translated as 100, 90, 50, and 10% cleared, respectively; cleared wetlands were calculated accordingly and are assumed to be drained, or partially drained.
  ii) Productive and unproductive forest figures were totalled for "uncleared" or forested land estimate; where the original wetland acreage exceeded the acreage that remained in forest, the difference was assumed to represent a minimal estimate of wetlands cleared, assumed to be drained or partially drained.

OUTPUT

Report: (as referenced)

RESULTS AND CONCLUSIONS

About 2.3 million ha of wetlands formerly existed in southern Ontario. A wetland loss of 1.2 million ha representing 55% of the total original wetland area of 2.1 million ha in 36 counties, is estimated.

The greatest losses accrue to Essex (135 701 ha or 93%), Kent (136 268 ha or 87%) and Lambton (127 696 ha or 79%) counties, where almost all wetlands have been reclaimed.

(Note: The study does not relate land use types to losses. But Brady (1978) asserts that these counties are noted for their large agricultural productivity; therefore, drainage and associated removal of forests on prime agricultural land is expected.)

PROJECT TITLE: THE ROLE OF AGRICULTURE IN DECLINING WETLANDS

REFERENCE

Bardecki, M.J. 1981. "The Role of Agriculture in Declining Wetlands." Ontario Wetlands Conference Proceedings. Ed. Anne Champagne. 18-19 September 1981, Toronto, Ontario. pp. 64-73.

AGENCY/CONTACT

Dr. Michal J. Bardecki
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OBJECTIVE

To determine the relative distribution and amount of municipal drainage expenditures by municipality in southern Ontario (1949-1979), and to estimate the extent and type of land-use impacts on wetlands in selected areas of southern Ontario (1966-1978).

STUDY AREA LOCATION

Southern Ontario, with detailed study of wetland losses on eight National Topographic Service map sheets: Parkhill (40 P/4); Tillsonburg (40 I/15); Wingham (40P/14); Dundalk (41 A/1); Oshawa (30 M/15); Fenelon Falls (31 D/10); Merrickville (31 B/13); Alexandria (31 G/7).

METHODOLOGY

Data Sources

(1) Records of annual amount of provincial grants drainage expenditures under the Drainage Act, by township (1949-1979)
(2) National Topographic Service map sheets (1966-1970) at a scale of 1:50,000
(3) National Air Photo Library black-and-white aerial photographs (circa 1978) at a scale of 1:10,000

Data-Handling Techniques

- Dollar values of drainage expenditures were converted to "present value", using Statistics Canada Gross National Expenditure deflator.
- Present expenditure value figures (expressed in "expenditure per unit area") for 1969-1979 were mapped by current municipality.
- Percentage of present value figures for 1949-1979 expended during 1969-1979 were calculated and mapped by current municipality.
- The area of wetland per township was assessed by encircling wetland areas as denoted by symbol on topographic maps and measuring the enclosed area with a dot planimeter.
- The proportions of township areas covered by wetland were calculated and mapped.
- Study areas were identified by randomly selecting eight topographic map sheets (study areas represent the coverage area for one map).
- Initial wetland areas (1966-1970) were measured from topographic maps as above.
- The extent and type of land-use changes to wetland areas 1966-1970 to 1978 were identified through the interpretation of stereo air photos.

- The percentage of initial wetland area lost per year was calculated for each topographic sheet and then mapped.

OUTPUTS

Report: (as referenced) includes small-scale maps showing:
- i) present value of municipal drainage expenditures per square kilometre (1969-1979)
- ii) percentage of present value of municipal drainage expenditures, 1949-1979 expended during 1969-1979
- iii) proportion of wetland by township (1966-1970)
- iv) wetland loss for study areas.

RESULTS AND CONCLUSIONS

Of an initial total of 23 736 ha of wetland area within the eight study areas, 317 ha (or about 1%) were drained in the period from 1966-1970 to 1978. The actual and proportional losses in southwestern Ontario (Parkhill, Tillsonburg, Wingham) far exceed those found elsewhere.

Agricultural drainage is the most significant process leading to the loss of wetland areas. In the areas studied, 85% of the area lost was attributable to agricultural drainage. The long history of agricultural development in southwestern Ontario has brought the expansion of agriculture into conflict with wetland areas. The indirect effects of drainage cover a greater area than the direct losses of wetlands for agriculture.

The pattern of municipal drain expenditures indicates two major centres of activity, one in southwestern Ontario and one in eastern Ontario. In the southwestern area, drainage activity is intense. In general, those areas exhibiting the greatest recent expansion are those on the fringe of previous drainage activity.

The area of early drainage intensity in the nineteenth century (i.e., Essex, Kent and Lambton counties) is the only significant area in the province where municipal drainage expenditures exhibited only "moderate" growth in 1969-1979. Elsewhere, the great expansion of drainage is in evidence.

Considering the great impact that agricultural drainage has on wetlands, there is a need for reconsideration of provincial drainage assistance programs.

COMMENTS

The estimates summarized above were generated to be used for the author's thesis:

Bardecki, M.J. 1981. "Wetland Conservation Policy in Southern Ontario: A Delphi Analysis." Unpublished Ph D. Thesis for the Department of Geography, York University. Downsview, Ontario. 467 pp.

PROJECT TITLE: THE DECLINE OF WETLANDS IN SOUTHERN ONTARIO

REFERENCE

Rutherford, L.A. 1979. "The Decline of Wetlands in Southern Ontario." Unpublished B.E.S. Thesis for the Department of Man - Environment Studies, University of Waterloo. Waterloo, Ontario. 68 p.

AGENCY/CONTACTS

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OBJECTIVES

To identify the attitudes toward, values of, and threats facing the wetlands of southern Ontario.

To document wetland loss, rate of decline and present extent of the Point Pelee and Lake St. Clair marshes (late 1800's to late 1970's).

STUDY AREA LOCATION

Southern Ontario, for a general assessment, with case studies of:
i) Point Pelee Marsh, i.e., wetlands within the present boundaries of Point Pelee National Park, as well as the area immediately north of the park known as Hillman Marsh.
ii) Lake St. Clair Marshes, i.e., wetlands situated on the east and southeast coast of Lake St. Clair, extending from the Walpole Island marshes in the north, along the shoreline of Lake St. Clair to the mouth of Tremblay Creek.

METHODOLOGY

Data Sources

(1) literature research
(2) historic topographic maps (1910-1918)
(3) National Topographic Service maps (1974-1976) at a scale of 1:50,000
(4) National Topographic Service maps (1924-1976) at scales of 1:25,000 to 1:63,360

Data-Handling Techniques

- "Original extent of marsh" estimates were obtained from an historical atlas for Point Pelee and early topographical maps for Lake St. Clair.
- Current estimates of marsh areas were made from measurements from recent topographic maps, modified in consideration of other estimates from recent studies.
- The rate of decline measurements were made from a sequence of five topographic maps covering a 50-year period.
- All marsh-area estimates were derived from maps and photos using a fixed-arm polar planimeter.

OUTPUTS

Report: (as referenced) includes small-scale maps showing:
i) the extent of the Point Pelee Drainage Scheme (1894-1895, 1904, 1909, 1914, 1953)

ii) the extent of the wetland resources in the Lake St. Clair area (1910-1920's, 1950's, 1970's).

RESULTS AND CONCLUSIONS

Point Pelee Marsh

The area of the Point Pelee Marsh declined by 71%, from 3 878 ha in 1880 to 1 126 ha in the mid 1970's.

Agricultural land drainage is by far the most significant factor contributing to the decline of wetlands in the Point Pelee area. The bulk of wetland drainage occurred in the 1890's when 50% of Pelee Marsh was converted into agricultural lands.

The rate of wetland decline in the Point Pelee area is affected by the presence of Point Pelee National Park. The park comprises between about 1 010 and 1 150 ha of wetlands which are protected from agricultural drainage pressure. There have been no major reclamation projects within the park's boundaries since its proclamation on May 29, 1918.

Lake level fluctuations may temporarily influence the extent of wetlands from year to year.

Lake St. Clair Marshes

The Lake St. Clair Marshes have experienced a total loss of 39%, from 17 303 ha in 1915 to an area of 6 684 ha in the mid 1970's. These figures represent an underestimation of actual losses, since much drainage activity occurred in this area in the late 1800's. Historical indications of the existence of over 18 500 ha of wetlands in 1880 imply that the current terrestrial marshlands represent approximately 10% of the original resource.

Agricultural land drainage is the major factor contributing to wetland decline in the Lake St. Clair area, particularly before 1900.

Cottage development, oil and gas drilling and industrial development have contributed in a minor way to the wetland loss. There is a greater wetland loss due to privately owned lands in the Lake St. Clair area as compared to the Point Pelee area.

Temporary losses result from the rise and fall of lake levels.

General

A wetland management and preservation policy must be formulated to ensure that wetlands will always remain, a step which must be taken while there are still wetland areas to preserve.

PROJECT TITLE: WETLAND MAPPING SERIES FOR SOUTHERN ONTARIO

REFERENCE

Snell, E. 1982. "An Approach to Mapping the Wetlands of Southern Ontario." Proceedings of a Pre-Conference Session of the Ontario Wetlands Conference. Ed. Michal J. Bardecki. Occasional Paper of the Department of Applied Geography, Ryerson Polytechnical Institute. Toronto, Ontario. pp 1-26.

AGENCY/CONTACT

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OBJECTIVE

To determine the location, extent and distribution of wetlands and wetland losses across southern Ontario (pre-settlement to late 1960's).

STUDY AREA LOCATION

Southern Ontario south of a line approximately from Bracebridge to Arnprior. Preliminary calculations of wetland losses were restricted to those townships in southern Ontario completely off the Precambrian Shield.

METHODOLOGY

Data Sources

(1) Canada Land Inventory Agricultural Capability Maps (mid-1960's) at a scale of 1:50,000
(2) Canada Land Inventory Land Use Maps (mid 1960's) at a scale of 1:50,000
(3) ARDA Report No. 8, Acreages of Soil Capability Classes for Agriculture in Ontario (1975)
(4) field reconnaissance
(5) black-and-white aerial photographs (1980) at a scale of 1:50,000

Data-Handling Techniques

- All saturated soils (i.e., those with a wetness limitation and all organic soils) were identified on CLI maps.
- Land-use maps were overlaid on the agricultural capability maps.
- Areas of natural vegetation (i.e., mature forest, immature forest and marshland) which coincided with saturated soil were identified as a current wetland.
- Areas of saturated soils which no longer had a natural vegetation cover, as denoted on the land use maps, were assumed to be lost wetlands.
- Area measurements for current and lost wetlands were determined by dot planimeter, and totals were calculated for each township.
- Saturated soil areas were totalled for each township from ARDA statistics and assumed to be acreage of pre-settlement wetlands.
- The difference between pre-settlement wetlands area and current wetlands area was calculated for each township and assumed to be the area of wetlands lost since European settlement.
- Map results were verified by field checking and interpretation of stereo air photos.

OUTPUTS

(1) Report: (as referenced) includes small-scale maps of:
i) pre-settlement distribution of wetlands by township
ii) distribution of wetland losses (to 1966) by township
iii) distribution of current wetland areas (as of 1966) by township.

(2) Maps: methodology was applied and completed on 125 NTS map sheets at 1:50,000, Wetland Mapping Series.

RESULTS AND CONCLUSIONS

The pre-settlement wetland area estimated for southern Ontario was 1 772 000 ha; the current area (circa 1970) is 541 000 ha for a loss of over 1 million ha or 70% of the original wetlands. Wetland in pre-settlement southern Ontario was calculated to cover 24% of the total area. This compares with a 7% value representative of the late 1960's.

Extreme southwestern Ontario and eastern Ontario had the highest concentrations of pre-settlement wetlands, as apparent from figures for Essex, Kent and Lambton counties in the southwest, and Dundas and Prescott counties in the east. Other moderate concentration levels occurred in the Niagara Peninsula, Dundalk Highlands and areas immediately south of the Canadian Shield.

An assessment of the distribution of losses reveals high totals in highly agriculturalized southwestern Ontario and the urbanized and agricultural "Golden Horseshoe", ranging from 80 to 95% of original wetland area lost. The lowest rates of loss have been in the northern sections of Bruce and Grey counties.

The distribution of remaining wetlands is characterized by large areas which have less than or equal to 5% of the township area as wetland, and almost all of the study area is 20% or less.

The statistics of areal loss revealed by this study substantiate already widely perceived trends of wetland loss. It is hoped that they will help spur further action in conserving the wetlands of southern Ontario and will direct the initial efforts to the most critical areas.

PROJECT TITLE: HABITATS PROPICES AUX OISEAUX MIGRATEURS
(FAVOURABLE MIGRATORY BIRD HABITATS)

REFERENCES

Le Groupe Dryade. 1980. "Habitats propices aux oiseaux migrateurs le long des rives: de la Rivière Outaouais, de la Rivière Richelieu, du Fleuve Saint-Laurant, de l'Estuaire du Saint-Laurent, de la Côte Nord du Golfe du Saint-Laurent, de la Péninsule gaspésienne, des Iles-de-la-Madeleine." Rapport présenté au Service canadien de la faune, Environnement Canada, Région de Québec. 65 p.

_____. 1981. "Habitats propices aux oiseaux migrateurs - Analyse des pertes de vegetation riveraine le long du Saint-Laurent entre Cornwall et Matane (1945-1960, 1960-1976)." Rapport présenté au Service canadien de la faune, Région de Québec. 27 p.

AGENCY/CONTACT

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OBJECTIVES

To inventory, map and measure the migratory bird habitat along the banks of the major watercourses of the southern portion of the province of Quebec, and to evaluate the trends in losses of shoreline habitat to other uses in three urban areas (1948-1978).

To identify the extent and types of man-made modifications of shoreline habitat along a specific length of the St. Lawrence River for two periods (1945-1976 and 1960-1976).

STUDY AREA LOCATION

An inventory of riverine habitat was completed for the shoreline bordering: the St. Lawrence River from Cornwall to Blanc-Sablon on the north shore and from Cornwall to the Matapedia River on the south shore; the Ottawa River from Lac des Deux-Montagnes to the area of Bristol, northwest of Ottawa-Hull; the Richelieu River, from Sorel-Tracy to the U.S. Border; the "Iles de-la-Madeleine" area in the Gulf of the St. Lawrence.

Three specific regions within the study area were chosen on the basis of their diversity and their proximity to urban areas, for a detailed assessment of habitat losses: the La Prairie Basin in the Montreal area; the Gentilly area, on the south shore of the St. Lawrence River a few kilometres downstream from Trois Rivieres; and the Kamouraska area.

Habitat loss was also studied on the north and south shores of the St. Lawrence River, from Cornwall to Pointe des Monts on the north shore and Matane on the south shore.

METHODOLOGY

Data Sources

(1) National Air Photo Library and Quebec provincial government black-and-white, colour and infrared aerial photography (1948, 1964, 1976)
(2) aerial photography (1945, 1960)

Data-Handling Techniques

- Base maps of the current (1976) configuration of riverine habitat of the entire study area were drawn by interpretation and analysis of the air photos. (1)
- 1948 and 1964 shoreline conditions for the La Prairie Basin, 1950 and 1966 shoreline conditions for the Gentilly area, and 1930, 1948 and 1961

shoreline conditions were also mapped (separately) by interpretation and analysis of air photos, and classified by the same system.
- All areas were measured with the aid of a dot grid (1 dot = 25 ha) to identify habitat changes, by classified vegetation type.
- Areas of "disturbance by man" and classified riverine habitat were identified by stereo air-photo interpretation, for the shoreline along the St. Lawrence River within three zones (fresh, brackish and tidal), and then mapped on acetate sheets, to be used as overlays on the 1976 base maps.

OUTPUTS

(1) Report: (as referenced)

(2) Maps: an atlas of 126 base maps at a scale of 1:20,000, with acetate overlays for 51 of those which detail the modifications over approximately 30 years.

RESULTS AND CONCLUSIONS

La Prairie Basin (1948-1976)

In the period 1948 to 1964, major changes were concentrated on the south shore of the La Prairie Basin along the St. Lawrence River, as the north shore had already witnessed much urban and industrial development. Some 1 808 ha were lost during this period following residential development, agricultural preparations for Expo '67, highway construction and dredging.

During the period 1964 to 1976, very little wetland loss (163 ha) was witnessed overall.

The Gentilly Area (1950-1976)

Major changes in this area occurred during the period 1966 to 1976, when development of an industrial park, infilling for the construction of a nuclear generating facility, and a man-made spit eliminated about 70 ha of shore marsh.

Kamouraska (1930-1975)

Major losses resulted primarily from the irrigation, diking and drainage of 102 ha of marshland of Kamouraska Bay for agricultural use, two-thirds of which occurred during the 1948-1961 period. The comparison between the 1961 and 1974 series of air photos reveals a halt to reclamation, while a significant vegetation change is noted.

St. Lawrence River: Cornwall to Matane (1945-1976)

Analysis of aerial photographs reveals losses of wetland habitat along the St. Lawrence River totalling more than 3 600 ha from approximately 1945 to 1975. More than 75% of the wetland area had been modified in the period 1945 to 1960, principally in the areas of the urban centres of Montreal, Trois-Rivières and Quebec City.

Losses of riverine habitat in the freshwater wetland zone (Cornwall to Grondines) amount to 2 625 ha. Most of these modifications (84%) occurred in the first analysis period (1945-1960). Losses were concentrated in the La Prairie Basin area, where about 47% of the modified area is located.

Wetland losses in the brackish and tidal-influenced areas (Grondines to Baie Saint-Paul-La-Pocatière) amounted to 608 ha, 60% of those losses occurring between 1945 and 1960. The majority of the losses occurred along the Quebec City shoreline and east to

RESULTS AND CONCLUSIONS (cont'd)

Cap Tourmente, and are associated with transportation and utility corridors and industrial land use.

Losses of saltwater wetlands in the south shore from La Pocatière to Matane are numbered at 238 ha, representing more than 7% of the original wetlands area. Again, losses occurred primarily in the first analysis period, and are concentrated in Kamouraska Bay, Cacouna and Rimouski. Kamouraska lost much wetland area to agricultural use in the 1940's and 50's; construction of port facilities accounted for significant losses at Cacouna between 1960 and 1975; and wetlands near Rimouski were converted before 1960 to residential, transportation, and public utility use.

The north shore of the St. Lawrence estuary from Baie Saint-Paul to Pointe des Monts has suffered less modification over the last 30 years, amounting to 62 ha.

The data indicates that the greatest portion of the total habitat area lost in the entire study area was attributable to (in order of importance): agricultural reclamation, infilling, residential use, dredging for marine transportation use, public utilities and industrial use.

APPENDIX 2

AGENCIES CONTACTED FOR WETLAND CONVERSION SURVEY

AGENCIES CONTACTED

FEDERAL GOVERNMENT DEPARTMENTS

Agriculture Canada

Charlottetown, P.E.I.
Edmonton, Alta.
Fredericton, N.B.
Guelph, Ont.
Ottawa, Ont.
St. John's, Nfld.
Swift Current, Sask.
Vancouver, B.C.
Winnipeg, Man.

Environment Canada

Atmospheric Environment Service
Downsview, Ont.

Canadian Forestry Service
Edmonton, Alta.
Fredericton, N.B.
St. John's, Nfld.
Ste.-Foy, Que.
Sault Ste. Marie, Ont.
Victoria, B.C.

Canadian Wildlife Service
Delta, B.C.
Edmonton, Alta.
London, Ont.
Ottawa, Ont. (H.Q.)
Ottawa, Ont. (Region)
Ste-Foy, Que.
Sackville, N.B.
Saskatoon, Sask.
Winnipeg, Man.

Environmental Protection Service
Dartmouth, N.S.
Fredericton, N.B.
Ottawa, Ont.
Toronto, Ont.
Dartmouth, Nova Scotia

Parks Canada

Calgary, Alta.
Cornwall, Ont.
Halifax, N.S.
Ottawa, Ont.
Ste-Foy, Que.
Winnipeg, Man.
Vancouver, B.C.

and various national parks

Inland Waters Directorate

Burlington, Ont.
Ottawa, Ont.
Vancouver, B.C.

Lands Directorate

Burlington, Ont.
Halifax, N.S.
Hull, Que.
Ste-Foy, Que.
Vancouver, B.C.

Fisheries and Oceans

Halifax, N.S.
St. Andrews, N.B.
Vancouver, B.C.
Winnipeg, Man.

National Capital Commission

Ottawa, Ont.

National Research Council

Ottawa, Ont.

United States Department of the Interior

Fish and Wildlife Branch,
Washington, D.C.

EDUCATIONAL INSTITUTIONS AND AFFILIATED RESEARCH CENTRES

Ontario

Carleton University

Brock University

University of Guelph

Lakehead University

Laurentian University

McMaster University

University of Ottawa

Queen's University

Ryerson Polytechnical Institute

Sir Sanford Fleming College

University of Toronto

University of Waterloo

University of Western Ontario

York University

Alberta

University of Calgary

University of Edmonton

British Columbia

University of British Columbia
Westwater Research Centre

Simon Fraser University

University of Victoria

Manitoba

Brandon University

University of Manitoba
National Resources Institute

New Brunswick

University of New Brunswick, Fredericton
Fire Science Centre

Newfoundland

Memorial University

Nova Scotia

Dalhousie University

Acadian University
Bedford Institute

Saskatchewan

University of Regina

University of Saskatchewan

Quebec

Laval University

University of Montreal

McGill University

College of Sherbrooke

University of Sherbrooke

PROVINCIAL GOVERNMENT DEPARTMENTS

Alberta

Agriculture
Energy and National Resources
Environment
Parks and Recreation
Transportation

British Columbia

Agriculture and Food (plus district offices)
Environment (plus district offices)
Forests
Lands, Parks and Housing
Recreation and Conservation

Manitoba

Consumer and Corporate Affairs
Environment
National Resources

New Brunswick

Agriculture and Rural Development
Environment
Natural Resources (plus district offices)

Nova Scotia

Agriculture and Marketing
Mines and Energy
Environment
Lands and Forests

Ontario

Agriculture and Food
Environment
Municipal Affairs and Housing
Natural Resources (plus district offices)
Transportation and Communications

Newfoundland and Labrador

Consumer Affairs and Environment
Forest Resources and Lands
Mines and Energy
Municipal Affairs
Rural, Agricultural and Northern Development
Newfoundland and Labrador Hydro Commission

Prince Edward Island

Lands and Forests
Community Affairs

Saskatchewan

Agriculture
Environment
Tourism and Renewable Resources

Quebec

Agriculture, Pêcheries et Alimentation
Énergie et Ressources
Environnement
Hydro-Québec

WETLAND WORKING GROUPS

National (CCELC)
Ontario
Saskatchewan
British Columbia

PUBLIC INTEREST GROUPS

Atlantic Center for the Environment, Ipswich, Massachusetts, U.S.A.
Calgary Field Naturalists, Calgary, Alta.
British Columbia Council of Forest Industries, Vancouver, B.C.
Canadian Federation of Naturalists, Ottawa, Ont.
Canadian Wildlife Federation, Ottawa, Ont.
Club des Ornithogues, Charlesbourg, Que.
Ecology Action Centre, Halifax, N.S.
Federation of British Columbia Naturalists Vancouver, B.C.
Federation of Ontario Naturalists, Don Mills, Ont.
Fédération Québec de la Faune, St. Eustache, Que.
Halifax Field Naturalists, Halifax, N.S.
International Union for the Conservation of Nature and Natural Resources, Switzerland
Manitoba Naturalists Society, Winnipeg, Man.
Manitoba Peatland Farming Association, Morris, Man.
National Parks Association, Toronto, Ont.
National Second Century Fund of British Columbia, West Vancouver, B.C.
Natural History Society of Prince Edward Island, Charlottetown, P.E.I.
Nature Conservancy of Canada, Toronto, Ont.
New Brunswick Federation of Naturalists, Saint John, N.B.
Newfoundland Natural History Society, St. John's, Nfld.
Ottawa Field Naturalists, Ottawa, Ont.
Province of Quebec Society for the Protection of Birds, Westmount, Que.
Saskatchewan Natural History Society, Saskatoon, Sask.
Wildlife Society of Canada, Ottawa, Ont.

NON-GOVERNMENT AGENCIES

Airphoto Analysis Associates of Canada Ltd., Toronto, Ont.

Beak Consultants Ltd., Calgary, Alta., Mississauga, Ont.

Canadian Resourcecon Ltd., Vancouver, B.C.

Comeau Ecological Consultants Ltd., Surrey, B.C.

Ducks Unlimited Canada Ltd.: Amherst, N.S. Barrie, Ont.; Brooks, Alta.; Edmonton, Alta., Kamloops, B.C.; Regina, Sask.; St. Jean, Que.; Surrey, B.C.; Tofield, Alta.; Victoria, B.C.; Williams Lake, B.C.; Winnipeg, Man.

Ecologistics Ltd., Waterloo, Ont.

Ecoplans Ltd., Edmonton, Alta.; Waterloo, Ont.

Groupe Dryade Ltē, Quebec City, Que.

Gulf Canada, Calgary, Alta.

International Range Remote Sensing Ltd., Kamloops, B.C.

Intera Environmental Consultants Ltd., Calgary, Alta.; Ottawa, Ont.; Vancouver, B.C.

Interdisciplinary Systems Ltd., Winnipeg, Man. Land Sense Ltd.: Burnaby, B.C.

J.C. Lee and Associates Ltd., Nanaimo, B.C.

McLean Forestry Services, Kamloops, B.C.

Ian MacPherson Associates Ltd., Toronto, Ont.

Marshall, Macklin, Monaghan Edmonton, Alta.

Grady Mann, Waterfowl Management Consultant, St. Paul, Minnesota, U.S.A.

Montreal Engineering Company (and subsidiaries): several locations.

Terry Noble, Environmental Surveyor, Thunder Bay, Ont.

Potash Corporation of Saskatchewan, Saskatoon, Saskatchewan.

Syncrude Canada, Edmonton, Alta.

Techman Ltd., Calgary, Alta.

Terrain Analysis and Mapping Services Ltd., Carp, Ont.

Washburn and Gillis Associates Ltd., Fredericton, N.B.

Western Ecological Services, Sidney, B.C.

Western Peatmoss Ltd., Vancouver, B.C.

POWER AUTHORITIES

British Columbia Hydro and Power Authority, Vancouver, B.C.

Newfoundland and Labrador Hydro, St. John's, Newfoundland (government department)

Ontario Hydro, Toronto, Ont.

Hydro-Québec, Montreal, Que.

West Coast Transmission Co., Vancouver, B.C.

Nova Scotia Tidal Power Corporation, Kentville, N.S.

APPENDIX 3

LETTER OF INQUIRY AND SURVEY FORM

Environment Canada | Environnement Canada
Environmental Conservation | Conservation de l'environnement
Ottawa, Ontario
K1A 0E7

Your file Votre référence

Our file Notre référence

April 5, 1982

Dear Colleague:

The conversion of wetland areas to agricultural, urban, transportation and other uses has become an issue of national significance. The Lands Directorate of Environment Canada has initiated a project to assess and evaluate nation-wide trends in the change of land use associated with wetlands. This study will provide the basis for the development of the wetland component of the Canada Land Use Monitoring Program (CLUMP).

Information on wetland change is likely to be of value to staff in your agency. May I request your assistance in compiling sources of information related to wetland conversion? All sources will be acknowledged and copies of our draft report circulated for review.

I have enclosed a contact sheet dealing with wetland change data in your agency, region on areas of expertise. Could you please return the completed information to me, along with any papers, reports, or references which you think may be useful.

If you have any questions concerning the project, please do not hesitate to contact Pauline Stewart at (819) 997-2240.

Your assistance is greatly appreciated.

Sincerely,

Clayton Rubec, M.Sc.
Environmental Scientist

Canada

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WETLAND CONVERSION IN CANADA
(Inquiry regarding information sources)

Agency: _____ Contact: _____

Address: _____ Position Title: _____

Tel No.: _____

1) Please list research activities (completed, current or planned) which relate to land use change on or adjacent to wetlands. Indicate (*) those which would be of particular significance to an assessment of the extent and rate of wetland conversion in Canada.

Project Title/Brief Description	Objective(s)	Time Frame

2) Please list activities which involve wetland evaluation and/or inventory

Project Title/Brief Description	Objective(s)	Time Frame

3) In your opinion, which wetland areas are of national significance and warrant the attention of a monitoring program. Please indicate (*) those which are currently under direct pressure for development.

APPENDIX 4

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ANNOTATED BIBLIOGRAPHY

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